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53rd CONFERENCE PART ONE

Pre-prints of Papers

NATIONAL SOCIETY FOR CLEAN AIR
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FUTURE EEC INITIATIVES

– By –

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The Community's First Environmental Action Programme adopted in 1973 spelled out the objectives and principles of the Community environment policy and listed a large number of essentially remedial actions. The Second (1977) and in particular the Third Environmental Action Programme (1983) stressed the necessity of a preventive approach.

As far as air pollution is concerned, the Community's efforts are focussed on the problems posed by acid rain, which is attributed to emissions of atmospheric pollutants.

In the last few years, the European Commission has initiated a significant programme of proposals with a view to a substantial reduction of emissions from large power plants and from motor vehicles as well as to the establishment of quality standards for nitrogen dioxide in the air, for the clean combustion of waste oils, and for the sulphur content of gas oils.

The efforts of the Commission to have its proposal for reducing emissions from large power plants adopted will be vigorously pursued. It is of prime importance that this proposal is adopted soon.

The Community will need to continue to play a constructive role in wider international frameworks such as in the Economic Commission for Europe where it is Party to the Geneva Convention on long-range transboundary air pollution.

The adoption of the Large Combustion Plants Proposal would open the possibility for the Community as such to sign the Protocol to the

Geneva Convention reducing SO2 emissions or transboundary fluxes by 30% by 1993.

The Commission's efforts in this field have received the support of the European Council which, in March 1985, raised the question of atmospheric pollution and asked for progress regarding abatement of pollution caused by large combustion plants.

In the specific sector of atmospheric pollution, an overall long-term strategy is currently being worked out to reduce air pollution with the aim of defining a comprehensive approach.

The environmental needs will certainly become even more imperative; the increasing interest in environmentally friendly goods, processes, products, wastes will be a challenge to industry.

In this context industry has an important role to play and even more immediately in 1987 which has been designated European Year of the Environment.

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NEW LEGISLATION PROPOSALS
AN INDUSTRIAL VIEW

— By —

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1. INTRODUCTION

For many years, the UK generally was very satisfied with its systems of air pollution control and management. Following the implementation of the Clean Air Act of 1956, the "smog" problem had virtually disappeared; through the BPM system and the Mahler criteria we had control methodology which could withstand rational, scientific examination and, simultaneously, take account of economic factors; and the whole was administered by the Alkali Inspectorate, a highly professional and experienced body, respected by industrialists and a model for the rest of the world to follow.

This very satisfactory state of affairs has led, in my view, to a certain degree of complacency, compounded by professional attention being diverted to major issues in other environmental elements such as solid waste and liquid effluent disposal, occupational health and product safety.

Many strong supporters of the undeniable advantages of the British system of control, myself included, had tended to overlook other developments world-wide which were, at first sight, not easily accommodated within the UK system. Some of these developments are scientifically-based and often global in nature, others are administrative / political / economic, as summarised in Figure 1.

As in all environmental issues which have become important over the last few years, political or pressure-group influences have become much more strongly pronounced than previously when, particularly in the UK, the diagnosis and solution of environmental issues

was almost entirely in the hands of the professional and scientific community. Rational demands for much more information and much less secrecy have also become irresistable.

It would be an overstatement to claim that a homogeneous "industrial view" exists on this range of complex issues. This paper will merely indicate areas where some changes in approach may be necessary and discuss whether these can be accommodated by the traditional UK system without fundamental or destructive change.

2. THE UK SYSTEM OF CONTROL

Processes thought to present the most difficult abatement problems are controlled by the Industrial Air Pollution Inspectorate, a branch of central government which, from April 1987, will become fully responsible to the Department of the Environment as part of the newly-announced HM Inspectorate of Pollution. Currently, the IAPI is responsible for the control of emissions to atmosphere from about 3400 such "scheduled" processes operated at about 2300 works. Most of these are in the chemical and metallurgical process industries, glass and cement manufacture and non-nuclear power generation.

All other processes can be subjected to a more limited form of control by the local authorities' Environmental Health Departments. In general, control is currently limited because their powers derive mainly from the nuisance provisions of the Public Health Acts.

For over a century, the IAPI and its predecessor, the Alkali Inspectorate, has controlled emissions to atmosphere by "Best

Practicable Means", summarised in Figure 2.

The principles underlying "BPM" (known as the Mahler Criteria) are, in my view, even more important and are often not stated. They are summarised in Figure 3.

These principles are usually incorporated in BPM Notes, published after detailed consultation with all interested parties including the industries concerned. The principles are usually translated into numerical criteria both for mass emissions and pollutant concentrations, an aspect of the UK system which is rarely perceived in mainland Europe where, at least in Latin countries, great difficulty is also experienced in understanding the word "practicable". Such criteria for cadmium emissions are shown in Figure 4.

Interpreted systematically by a knowledgeable inspectorate the BPM system appears to provide a fully effective system of environmental protection which at the same time takes account of costs when criteria are being set. Why, then, has the system come under such serious attack, not only by the extreme environmental interests but also by the regulators and some industrialists in mainland Europe?

Apart from the real difficulties of interpretation and understanding which I referred to above, I believe that the BPM system has to accommodate the following points, summarised in Figure 5.

3. DESIRABLE DEVELOPMENTS IN THE UK SYSTEM

My judgement is that many of the above criticisms apply equally to other systems of air pollution control and that they can in fact

be accommodated within the BPM system as well as the fixed limits system. Furthermore, it is wrong to judge criteria systems in isolation from implementation and inspection systems. All are inextricably bound together in the system for the overall management and control of air pollution.

Taking the above points in turn, it has to be admitted that the BPM system is essentially national in character - almost parochial since it is applied individually on a plant by plant basis. It was not designed to cater for problems such as acid deposition and the greenhouse effect which have been identified only during the past decade or so. In the Acid Deposition controversy the unknowledgeable or the mischievous have equated BPM with a "tall stack policy", obscuring the fact that BPM requires FIRST a reduction of emissions to the minimum practicable, FOLLOWED BY effective dispersal of the residuum, usually through a tall stack.

In fact, the differences between the BPM and the fixed emission systems comes down to the permitted emission levels. In mainland Europe, particularly W. Germany, these are being set increasingly at the limits provided by best available arrestment and process technology, regardless of local environmental requirements or cost. The BPM criteria have always implied the use of best available technology "to reduce emissions to the minimum practicable level", but the requirement is modified by the need to take economic factors into account. Neither system defines time-scales clearly - even the TA Luft regulations apply to new plants only and are discretionary for others.

The lack of clear correlations between ambient air quality standards and stack emission

criteria is common in both the BPM and the fixed emission value systems. It will presumably remain so until a precise method of accounting for emissions from diffuse and mobile sources is worked out. This should not be accepted as a specific criticism of BPM.

In recent years it has become appreciated increasingly that fugitive emissions (eg from dumps or roof vents) can be as important as emissions from chimneys, particularly for processes handling particulate solids. This is now fully recognized in the UK and taken account of by IAPI in their BPM "Guidance Notes", through the use of covered stores and conveyor systems and adequate ventilation/arrestment at transfer points. In this regard, I believe that the UK is in advance of some other countries which make no provision either for practical advice or regular, professional inspection.

I believe it is a valid criticism of the UK system that insufficient data are easily available to permit accurate evaluation of its effectiveness. In fact, a great deal of information is published, both through the Chief Inspector's Reports and those of the local inspectors and through data submitted to the very large number of local liaison committees which now exist. However, my belief is that the virtues of the UK system would become much more obvious to all concerned, to the benefit of both UK regulators and industry, if the following steps were implemented.

A further valid criticism of the present UK system of Air Pollution Control is that it is over-centralised and systems for the effective control of non-scheduled works require significant tightening. The EC Directive 84/360 ("The Combatting of Air Pollution from

Industrial Plants") may provide the opportunity to remove these criticisms by requiring more detailed control of some processes not currently under IAPI control (eg some iron foundries, glass and ceramic factories, waste incineration plants) and requiring "authorisation" of plants both before operation and if subjected to signifcant modification. If HMG avails itself of this opportunity, I believe that industry will be generally supportive, provided that workable arrangements can be made to develop appropriate national Guidance Notes on the BPM pattern. Local Environmental Health Officers are well-qualified professionals, though unlike members of the IAPI they have to deal with a very wide range of problems rather than concentrating solely on issues arising from the process industries. In addition, there are many hundreds of EHOs (compared with 40 or 50 Industrial Air Pollution Inspectors) and, potentially, many hundreds of processes for control. Hence, it is vitally important that agreed central guidance be given and adequate time allowed to complete the considerable task of developing the notes and allowing EHOs to develop experience of the processes newly under their control.

If HMG grasps this opportunity, I believe that significant improvements in air pollution control will result and some of the mysteries of the UK system perceived in mainland Europe will disappear.

4. CURRENT AND FUTURE CONCERNS

In the UK administrative context, strong support from the majority of the process industries will be given to HMG's recent decision positively to locate the IAPI within the Department of the Environment. Apart

altogether from national views on the subject, it has always appeared strange - perhaps typically British - that the Inspectorate responsible for Air Pollution Control was not clearly part of the Department of the Environment. Although ill-defined at present, significant potential advantages can be envisaged for the combined Pollution Inspectorate, particularly if a workable "best practicable environmental option" (BPEO) system can be evolved. As noted earlier, industry will generally support the increased involvement of local authority Environmental Health Officers in the management of processes currently not under IAPI control, provided that they operate on a BPM basis following guidance notes prepared nationally with inputs both from the IAPI and the industries concerned.

I believe that generally support will also be forthcoming for the more liberal publication of information relating both to consents and performance against consents, monitoring data, interpretative material etc, as is already done to some extent in relation to liquid effluents.

It should be clear from the earlier sections of this paper that I regard preservation of the BPM system administered and implemented by the present highly professional IAPI as essential to balancing effective control of emissions to atmosphere with industrial practicalities on a basis that industry understands and trusts. However, developments in the traditional role of the IAPI are essential, as outlined in Figure 7.

In my judgement, and I believe that of the process industries at large, there is no scope for economies in our present number of 40 or 50 Industrial Air Pollution Inspectors and any proposed economies would not be justified.

British industry needs to be seen to be performing consistently to high, scientifically justified, environmental criteria.

In a broader context, whilst the process industries welcome substantial parts of the proposed EC 4th Action Programme, we must continue to be concerned about some aspects of it, particularly the expression of underlying principles in slogans such as "Prevention is better than Cure" and "The Polluter Pays Principle".

Of course, in the general sense, prevention is better than cure - very few of us could or would argue with this proposition. But we are suspicious that the principle could be used to justify almost any regulations to control almost any problem, real or imagined.

As I stated earlier, scientific PROOF is rarely attainable in the environmental world but, at least, we would like significant scientific EVIDENCE backed up by some sort of valid cost-benefit analysis. We are not infrequently told that 'the politics cannot wait for the science'. Maybe - but regulators should also be professional in withstanding extreme and unsubstantiated demands at least until a scientific consensus, as well as a real political consensus, can develop. Rapid catastrophes are now mainly confined to major accidents; time-scales in environmental issues usually allow the collection and interpretation of scientific data and the development of apposite solutions if necessary, and we should make good use of this time before embarking on over-hasty regulation.

The Fourth Action Programme also re-endorses the 'Polluter Pays Principle' and believes that it should be applied more widely in view of its

key importance. Surely everyone by now must know that it is only the consumer who can pay, directly or indirectly, for the costs of implementing regulatory criteria. If profit margins, already slim in our industries, are reduced further, then bankruptcy can be the only result. Whilst we recognize that, these days, our regulators have to be good politicians, can we not have some clarification of the interpretation and meaning actually placed on these attractive-sounding slogans? I am sure that this would do wonders for our relationship with the regulators.

Turning to more positive aspects of the programme, industry has come increasingly to recognize the international ramifications of environmental issues, particularly air pollution. So we welcome proposed attempts to harmonize international environmental criteria between the developed and the developing world and hope very much that this will also include harmonization of implementation, including inspection and monitoring. We also welcome the recognition of the problem presented by the continual tightening of regulatory criteria in each environmental element and also the fact that the transfer of pollutants from one environmental element to another will not be beneficial overall. Whilst "pollution transfer" is not yet a generally serious issue, it is likely to become much more important in the future. We thus place considerable emphasis on the "best practicable environmental option" approach and hope that it can be harmonized with the "multimedia" approach outlined in the 4th Action Programme. Working out the difficult administrative implications of BPEO will doubtless be a major task of the new Pollution Inspectorate within the DOE.

5. CONCLUSIONS

(i) Public concern about air pollution remains at a high level and will continue to be sustained by media and pressure-group interest.

(ii) It follows that there is justification for the publication of more information, in assimilable form, relating to criteria and performance against criteria.

(iii) The "best practicable means" approach, backed up by effective inspection/implementation and Guidance Notes, remains a highly effective means of balancing environmental protection with industrial economics. In the UK, greater decentralisation is necessary and will be effective if it is based on BPM principles.

(iv) Directives etc from the EC will become the major influence in determining UK control policy and criteria. Hence it is essential to devote greater attention to harmonizing the BPM approach with the fixed emissions approach and, particularly, with air quality standards. More consideration will also be necessary for the control of diffuse as well as fixed sources of emission.

(v) Politicisation of the framework for air pollution control and other environmental issues will continue but priority assessment and criteria establishment must be based on environmental need assessed scientifically, not slogans. Over-hasty legislation and regulation must be avoided if the European process industries are to remain world-competitive.

(vi) As criteria in each environmental element tighten, there will be increasing need for a "best practicable environmental option" approach and for this reason the new Pollution Inspectorate, within DOE, is strongly endorsed.

FIGURE 1

RECENT AIR POLLUTION ISSUES

SCIENTIFIC
- Acid Deposition ("Acid Rain")
- Chlorofluorocarbons and Stratospheric Ozone
- The "Greenhouse" Effect
- Consequences of Major Accidents eg Bhopal, Mexico City
- Chernobyl and the nuclear issue
- The importance of diffuse as well as fixed emission sources

ADMINISTRATIVE/POLITICAL/ECONOMIC
- Increasing influence of EC Directives
- Regulatory AND INDUSTRIAL pressure for harmonization of criteria
- Pressure from non-EC countries
- BPM in relation to Fixed Emission Limits and Air Quality Standards
- Tightening of criteria in all environmental elements - is there a place for BPEO?
- Location of IAPI within the UK Regulatory System
- Decentralisation of administration to the local authorities

FIGURE 2

BPM DEFINITIONS

PRACTICABLE - "reasonably practicable having regard, amongst other things, to local conditions and circumstances, to the current state of technical knowledge and to the financial implications"

MEANS - "the design, installation, maintenance and manner and periods of operation of plant and machinery and the design, construction and maintenance of buildings"

FIGURE 3

PRINCIPLES UNDERLYING BPM

- No emission can be tolerated which constitutes a demonstrable health hazard, either short - or long-term.

- Emissions in terms of both concentration and mass must be reduced to the lowest practicable amount.

- Having secured the minimum practicable emission, the height of discharge must be arranged so that the residual emission is rendered harmless and inoffensive. (As a general rule of thumb, a maximum ground level concentration of one-fourtieth of the occupational exposure limit is taken as an acceptable level).

FIGURE 5

CRITICISMS OF "BPM" APPROACH

- Global atmosphere must be protected as well as near neighbours.
- Impossible to reconcile economic factors with need to reduce emissions to "the lowest practicable amount".
- No clear method for relating permitted stack emissions to ambient air quality criteria.
- Applies to point sources only; fugitive emissions cannot be quantified.
- Applies to stationary sources only; mobile and diffuse sources cannot be covered.
- No clear time scale for upgrading older plant, ie substantial differences in performance between current and older plants.
- Effectiveness cannot be judged because data are not published.

FIGURE 4

PRESUMPTIVE LIMITS FOR CADMIUM EMISSIONS

Class I Works < 7000 cfm (200 m^3/min)

0.03 grain per cubic foot (0.070 g/m^3) (as Cadmium) and

0.3 lb/hr. (0.13 kg/hr) mass emission limit

Class II Works 7000 - 140,000 cfm (200 - 4000 m^3/min).

0.005 grain per cubic foot (0.012 g/m^3) and 1.5 lb/hr. (0.7 kg/hr)

Class III Works > 140,000 cfm (4000 m^3/min)

Each case judged on its merits

	Plant Size (cfm) x 10^3	Plant Size m^3/min	lb/hr	Kg/hr	gr/ft^3	g/m^3
Class I works	1	30	0.26	0.1	0.03	0.067
	2	60	0.30	0.1	0.017	0.037
	3	85	0.30	0.1	0.012	0.027
	4	110	0.30	0.1	0.009	0.020
	5	140	0.30	0.1	0.007	0.014
	6	170	0.30	0.1	0.006	0.014
	7	200	0.30	0.1	0.005	0.012
Class II works	10	280	0.43	0.2	0.005	0.012
	20	570	0.86	0.4	0.005	0.012
	30	850	1.29	0.6	0.005	0.012
	40	1130	1.50	0.7	0.0044	0.009
	50	1400	1.5	0.7	0.0035	0.008
	60	1700	1.5	0.7	0.0029	0.007
	70	2000	1.5	0.7	0.0025	0.006
	80	2260	1.5	0.7	0.0022	0.005
	90	2500	1.5	0.7	0.0019	0.0044
	100	2800	1.5	0.7	0.0018	0.0041
	120	3400	1.5	0.7	0.0015	0.0035
	140	4000	1.5	0.7	0.0013	0.003
Class III works	Greater than 140	4000	Greater volumes judged on merit			

FIGURE 6

PUBLICISING "BPM"

- Publish individual plant consents in the context of the overall production process.
- Publish individual plant performances with interpretation in local Inspectors' reports.
- Publish Chief Inspector's Report in German and French as well as English.
- Implement an independent auditing system to identify any current weaknesses in the UK system and possible future problems in meeting EC requirements.

FIGURE 7

IAPI DEVELOPMENTS

SCIENTIFIC/TECHNICAL

- Effective practical correlations between stack emission criteria and air quality standards.

- Criteria establishment - BPM or best available technology or what?

- Detailed assessment of the impact of EC Directives on UK industry.

ADMINISTRATIVE/POLITICAL

- INFLUENTIAL inputs into EC Directive Development.

- Assisting decentralisation of UK systems, particularly through the development of BPM guidance notes for processes not currently scheduled.

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NEW LEGISLATION PROPOSALS – A LOCAL AUTHORITY VIEW

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THE NEED FOR CHANGE

The spectacular success of the Clean Air Acts cannot be denied or ignored, but equally we cannot rest on our laurels. Some 30 years have passed since that revolutionary legal framework for controlling smoke, grit and dust from combustion processes, to be followed some 13 years later by chimney height controls which were independent of the planning process. However, the powers available to local authorities to control air pollution from non combustion processes are firmly rooted in the last century. I refer to the nuisance provisions of the Public Health Acts, the origins of which are to be found in the 1875 Public Health Act. These powers permit a local authority to take action in cases of nuisance or prejudice to health caused by "any dust or effluvia from any trade or business". By definition, local authority officers are reacting to a situation or problem after it has occurred, after people have suffered nuisance and inconvenience and where in some cases there has been a serious risk of health effects. The work involved in investigating complaints, obtaining evidence, negotiating with the firm concerned as well as keeping residents fully informed is highly staff intensive. In addition, reacting to problems after they have arisen when they could have been anticipated at the plant design or planning stage or prevented by a 'best practicable means' approach is notoriously inefficient both from the industry and local authority standpoint. The ability to anticipate nuisance in the noise control provisions of the Control of Pollution Act has proved beneficial to all parties concerned, not least to the residents who would have been affected and, in the case of construction site noise, to the contractor who, with the local

authority, can sort out the problems in advance of the commencement of work.

To add confusion to inadequate, out-of-date powers, the Industrial Air Pollution Inspectorate (IAPI) and local authorities operate legislation which is substantially different, with fundamentally different approaches providing local authorities with much less effective control over industry, particularly in relation to non combustion processes. The Royal Commission on Environmental Pollution commented in its Fifth Report (1):-

> "We can see no good reason for these different legislative provisions for the control of emissions of different kinds. Moreover, these legislative differences appear to us to be inimical to the flexibility in control arrangements that we should like to see. The system has developed piecemeal as the need for action to deal with different aspects of air pollution was appreciated. The time has now come for new, comprehensive legislation to be enacted, appropriate to a flexible division of control between central and local government, and providing for the same basis of control whether industrial air pollutants originate from combustion or non-combustion processes."

The Royal Commission also made the following recommendations relevant to this subject:

- control of industrial air pollution should continue to be shared between local authorities and a central inspectorate;
- control of industrial emissions should continue to be based on the principle of "best practicable means";

- unless there are grounds for control by the central inspectorate, local authorities should control all those works which lie within their technical competence;
- there should be new comprehensive legislation to cover all aspects of industrial air pollution;
- wider participation is needed in the determination of the best practicable means. The Department of the Environment should consider what machinery should be introduced for this purpose.

After prolonged consideration by two successive governments, the Government gave its response to the Royal Commission's Fifth Report in 1982 (2).

> "The Government recognise that control on the basis of bpm requirements can at present be applied fully in a flexible way only by the Inspectorates. The Government accept that there are some processes for which it would be desirable to provide for similar local authority control, although they consider that this may not be appropriate for all processes.
>
> Other factors have arisen since the Royal Commission's report which have a bearing on the need to review air pollution control legislation.
>
> The Government have therefore decided that a comprehensive review of air pollution control legislation shall be undertaken. It is envisaged that a consultation document will be issued discussing options for effective powers that could be made available as necessary to either the central inspectorate or local authorities."

Now, 30 years on from the first Clean Air Act, the time is long overdue to promulgate air pollution control legislation which is not only appropriate to the present time but which will provide a sound basis to carry forward into the next century and, at the same time, enable the UK to meet its obligations to Europe. Where the Royal Commission on Environmental Pollution and the Local Authority Associations have failed to persuade or coerce Government into action, the EEC has succeeded, for if there is to be effective implementation of the Framework Directive (84/360/EEC) there has to be a review of the relative roles of the central inspectorate and local authorities and a comprehensive review of, and amendments to, the legislation.

A SUGGESTED FRAMEWORK

The Government's review has taken a long time and at the present time (July 1986) still has not been published. However, the Royal Commission on Environmental Pollution not only made the case for legislative and administrative change but also provided broad guidelines for a new and more effective means of industrial air pollution control. More recently, representatives of the enforcement agencies, professional bodies and industry have considered the way forward.

Legislation

Any new system will need to incorporate the following principal elements:

i) the central inspectorate and local authorities operating the same legal code, thus giving local authorities effective

controls over processes which present problems which cannot be handled under the Clean Air Acts or Public Health Acts:

ii) the ability to comply with the EC Framework Directive;
iii) registration of processes;
iv) prior approval of best practicable means;
v) improved public access to information;
vi) a co-ordinating body to achieve uniformity and consistency of approach to administration and enforcement.

Any new legislation or administrative arrangements should provide for a 'Schedule of Processes' to be in two parts: one part to be the responsibility of the Industrial Air Pollution Inspectorate (IAPI) and the other the responsibility of district councils. The schedules should be flexible in the sense that there should be the ability to transfer responsibility for enforcement from IAPI to local authorities as circumstances and the need for central control change. The schedules should comprise:

i) existing scheduled processes
ii) processes listed in Annex 1 of the EC Framework Directive;
iii) certain processes which give rise to recurring air pollution problems and which are not included in i) or ii) above, eg. processes involving the handling of animal products and processes emitting solvent vapours.

Authorisation Procedures

The registration requirements for scheduled processes are currently set out in Section 9 of the Alkali etc. Works Regulation Act 1906 (as amended) and in the Alkali Works (Registration) Order 1957 (as amended). The principal

elements of these provisions are:

i) initial registration of new plant is conditional upon prior approval of best practicable means;
ii) registration is renewable on an annual basis;
iii) certificates of registration relate to the category of scheduled process rather than specific items of plant.

The following is suggested as a future system.

1. A certificate of registration to be issued for each scheduled process on site, ie in either part of the schedule.
2. The certificate to include a brief description of the plant and process to which the registration refers, together with a brief statement of the bpm requirements relating to that plant.
3. The initial granting of the certificate of registration and any subsequent amendment or renewal to be subject to prior approval by the appropriate enforcing authority.
4. The certificate to be valid for three years.
5. A register of all certificates in force to be maintained by the enforcing authorities for all premises within the scope of the legislation within their area. The register to be available for public inspection.

Co-ordinating Body

Consistency of approach and enforcement is a matter which concerns not only industry but also the enforcing authorities and the professionals and is a problem which must be recognised. Arrangements must be made to address this issue and to provide a forum to

bring together in one central body all those with a direct interest and involvement in industrial air pollution control such as: the central inspectorate, Department of the Environment, local authority associations, professional institutions and of course, industry.

Matters for consideration by the Co-ordinating Body would be:

- matters relating to the implementation and enforcement of the legislation in respect of the control of emissions to atmosphere from scheduled processes;
- exchange of information on enforcement practices, liaison at the local level, standards of recording and reporting, training of inspectors and to provide appropriate guidance;
- preparation, publication and review of bpm notes for all scheduled processes through ad hoc specialist working groups involving the industries concerned;
- review of the scheduled processes and their allocation between local and central control and to make proposals for changes;
- production of an annual report covering all scheduled processes including those under local control.

CONCLUSION

The changes suggested and outlined in this paper can be brought about administratively by new Regulations under the Health and Safety at Work etc. Act or, of course, can be incorporated in a comprehensive review of air pollution legislation and any resultant comprehensive legislation. One thing is certain: given the length of time this issue has been on the agenda, the need for

consultation on any proposals, and the impending inplementation of the EC Framework Directive, time is of the essence. We in local authorities are ready and willing to take on new enforcement responsibilities which will actually improve our efficiency as well as our effectiveness.

References

1 Royal Commission on Environmental Pollution - Fifth Report Air Pollution: An Integrated Approach 1976.

2. Air Pollution Control. The Government Response to the Fifth Report of the Royal Commission on Environmental Pollution.
Pollution Paper No. 18 (1982).

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THE ADVANTAGES OF CHP SYSTEMS

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SYNOPSIS

The Government has designated 1986 as Energy Efficiency Year under the slogan, "Get more for your Monergy".

Mr. Peter Walker has confirmed that everyone - the public, the business community, local Government and central Government - must "become conscious of the need to stop the scandalous waste of money and energy in which Britain indulges at the moment".

According to the EEO £35 billion per annum is spent on energy in Britain and the Government's target since the launch of its energy efficiency initiative 2 years ago has been to reduce the bill by £7 billion per annum, or 20%, and it is understood that the EEO are incurring promotional expenditure in the order of £4 million to £5 million in this context.

The Paper considers the inland consumption of primary fuels in the United Kingdom and in particular the total energy input into power stations in 1983 which was 25.4 (tmt) of which 17.4 (tmt) was lost in conversion, distribution and own use. i.e. 68.5%.

This waste of primary energy exceeded the British Gas Corporation sales of 17.3 billion therms in 1983/84 and also exceeded the total requirements of either domestic users (15.5 tmt) or other "industry" (14.0 tmt). The basic principles of Combined Heat and Power generation are examined and it is demonstrated that the conventional production of 28 units of power and 52 units of heat requires an input of 80 + 65 = 145 units of primary energy and rejects 52 + 13 = 65 units as waste. The CHP station, however, produces the same quantities

of power and heat energy (28 + 52) using only 100 units of primary energy i.e. 45 units less, representing a fuel saving of 31%.

The benefits of CHP are summarised as being:

1. Improved national energy efficiency and preservation of national energy resources.
2. Security of national energy supply.
3. Reduced dependence on imported fuels.
4. Reduced environmental pollution.
5. Improved balance of payments.
6. Cheapest heating (in conjunction with DH).
7. Ability to utilise low cost energy sources, i.e. refuse incineration.
8. Investment in British engineering, construction and service industry, skills.
9. More jobs (estimated at between 300,000 and 500,000).

The Energy Debate and CHP in the United Kingdom are considered in relation to Energy Paper 35, the Atkins Report, the Reports of the Select Committee on Energy and the response of Government. The present situation with regard to city-wide CHP is discussed with particular reference to the 6 cities currently undertaking detailed studies, together with the implications of the 1947 Electricity Act, the 1983 Energy Act, the Tariff structure for electricity generated privately and matters affecting the rating of city-wide CHP schemes. Specific comment is made on the suggestion that the same criteria for public sector investment should be applied to both "supply" and "demand" management.

Institutional arrangements are discussed together with details of progress in Europe and the USA and the Paper confirms that the benefits of CHP/DH are widely recognised in most IEA member countries and in the USA and USSR and CHP/DH can be described as a "hedge"

technology to reduce the adverse effects of oil supply disruption and to increase fuel flexibility.

The need for a higher degree of devolution of responsibility to regional or municipal levels is discussed in order to take account of local and regional needs. The Atkins Report estimated that implementation of CHP generation in the UK could achieve energy consumption savings in the order of 14 mtce or (3.5 tmt) with rates of return on investment ranging from 5 to 12%.

The Paper also examines the environmental benefits obtainable from the use of CHP systems with particular reference to current developments and legislative aspects in Denmark in relation to refuse incineration in conjunction with CHP.

The paper concludes that the major benefits of the implementation of CHP/DH and industrial CHP to the UK have been clearly demonstrated and Government has a clear duty to formulate an energy strategy, or policy, in national terms, if the levels of energy efficiency expounded by the Secretary of State for Energy are to be achieved.

The ability, the technology, the skills and finance are available to do this; it is only, in the opinion of the author, the national "will" which is missing.

It seems unwise to ignore the massive potential for energy conservation which CHP can contribute for the United Kingdom when we observe the increasing importance attached to it by our fellow European partners, and IEA member countries.

INTRODUCTION

World resources of fossil fuels are fundamentally finite and the rate at which energy is currently being consumed is increasing in overall terms, as is world population. However, as a result of the 1973 oil crisis, total energy consumption in the UK for 1983(1) was 313 million tonnes of coal equivalent (mtce), compared with 354 mtce in 1973 and the urgent need for continuing and more effective energy conservation is now fully appreciated.

Examination of the percentage shares of the various primary fuels (on a fuel equivalent basis) for the years 1973 and 1983 demonstrates clearly the shift in consumption from petroleum to gas and the increased share of nuclear electricity.

In 1973 the combined shares of petroleum and natural gas amounted to 58.9% (208.4 mtce) and in 1983 although their combined share was still 57.8% (180.9 mtce) the petroleum share fell by 12.5% whilst the natural gas share rose by 11.4%.

In individual terms petroleum consumption fell by 58.1 mtce, or 35.4%, whilst natural gas consumption rose by 30.6 mtce, or 69.2%. Coal consumption fell by 21.5 mtce whilst the share of nuclear electricity rose by 8 mtce. It is significant that over the period 1975-1983 UK import dependency(2) fell from 44.4% to 0% and indeed total net arrivals were -58.5 mtce.

The UK energy flow chart 1983(3) indicates that of the 120.8 thousand million therms supplied some 77.7 (tmt) were used for energy input, the remainder going to exports, bunkers, and non energy users. Of this 77.7 (tmt) energy input only 54.2 (tmt) arrived with the final energy

users with 23.5 (tmt) losses being incurred in conversion and distribution, etc. Of this figure 17.4 (tmt) was lost in coal fired power stations. The total losses of 23.5 (tmt) represent 44% of the total final energy use of 54.2 (tmt).

The future impact of nuclear power generation on the UK energy balance is presently unclear since aspects of its technology, operational and safety procedures, waste disposal, etc., have been the subject of intense debate since the Chernobyl "incident". It is the author's view that in any event it cannot be considered as being capable of taking over our current fossil fuel commitment and the contribution made by "renewable" energy sources is unlikely to be significant in overall terms in the foreseeable future.

Domestic consumers utilise 15.5 (tmt) or 28.6% of the 54.2 (tmt) final energy usage and of this 15.5 (tmt) 8.9 is gas, 2.3 coal and 2.8 electricity. The British Gas Corporation(4) anticipated that growth in all markets should raise gas sales from 17.3 billion therms in 1983/84 to around 20 billion therms per annum by 1990 and that thereafter consumption levels will remain substantially the same. The total energy input into power stations in 1983 was 25.4 (tmt) and of this 17.4 (tmt) was lost in conversion, distribution and own use, i.e. 68.5%. This loss of 17.4 (tmt) or 69.6 mtce exceeds the total British Gas Corporation sales(4) in 1983/84 of 17.3 (tmt).

The average thermal efficiency of the 176 (steam) generating stations in Great Britain(5) in 1984 was 32.1%, even though the proven technology of Combined Heat and Power Generation (CHP) exists and is capable of raising thermal efficiencies to between 75% and

80%. The Atkins Report(6) estimated that the implementation of CHP generation could achieve savings in UK energy consumption in the order of 14 mtce(or 3.5 tmt) with rates of return on investment ranging from 5-12%.

1986 has been designated "Energy Efficiency Year" and "Monergy 1986" is the current catchphrase adopted by the Energy Efficiency Office (EEO) to draw our attention to the urgent need for national energy conservation. The House of Commons Select Committee on Energy report on the EEO (published at the same time as The Secretary of State for Energy launched 1986 Energy Efficiency Year) recommended that public spending on energy efficiency be given as great a claim on resources as investment in new sources of supply. Investment in CHP generation on the scale referred to in the Atkins Report(6) would improve our national energy efficiency dramatically.

UK energy consumption patterns are the direct result of policies and attitudes of successive Governments and in order to evaluate the effects of such policies it is necessary to consider them in an international perspective.

THE PRINCIPLES OF CHP GENERATION

CHP is not a new technology and its principles have been fully appreciated and exploited for many years. European nations and the USA and USSR have been investing heavily in CHP since the 1950s.

The first industrial CHP scheme in the UK was probably that at the Singer Factory on Clydebank in 1898 and CHP/DH (district heating) followed at Bloom Street in Manchester in 1911. It is estimated that there are some 140 industrial CHP schemes in the UK and currently

54 of these supply electricity to Area Boards.

Conventional (steam) power generating station design has evolved on the principle of attaining the maximum efficiency in conversion of primary fuel energy (heat) to mechanical energy (turbine shaft rotation) and this automatically results in the necessity to reject (waste) heat as close as possible to ambient temperature. It follows therefore that conventional electricity generation produces vast quantities of low grade heat. A 2000 MW (e) station will, typically, require approximately 4500 x 10 litres of water per day with a cooling water temperature of 30° C. This represents a level of water usage comparable with the average flow of the River Thames at Teddington(7).

The total 'waste' energy from our power stations in 1984 was the equivalent of 17.4 (tmt) which exceeded(3) the total requirements of either domestic users (15.5) or "other industry" (14.0). Power stations are, however, being built elsewhere to reject (waste) heat at a higher, and economically useful temperature - with a small reduction in electricity generation.

Figure 1 shows the efficiency of conventional (steam) generation plant and indicates that for every 100 units of primary energy input 66 units are rejected as waste. This can be compared with Figures 2 and 3, respectively, which indicate the substantial benefits in thermal efficiency obtainable with CHP.

Figure 2 relates to large scale (city wide) CHP and shows that for every 100 units of primary energy input only 20 units are wasted. 28 units of electrical power (as opposed to the 34 in Figure 1) are produced, together with an

additional 52 units of heat, some 15 of which will subsequently be dissipated in distribution mains losses.

Figure 3 demonstrates the even higher efficiency attainable by small scale CHP where waste is now reduced to as little as 4 + 12 or 16 units.

Figure 4(8) represents an alternative method of comparison between (1) separate (conventional) heat production, and (2) CHP, or co-generation.

The conventional production of 28 units of power and 52 units of heat requires an input of 80 + 65 = 145 units of primary energy and rejects 52 + 13 = 65 units as waste. In the CHP station, however, the production of the same quantities of power and heat energy (28 + 52) is achieved using only 100 units of primary energy, i.e. 45 units less, representing a fuel saving of 31%.

The selection of plant is one of the most important factors in evaluating CHP schemes and it has been the subject of numerous papers and reports including the Atkins Report(6), Technical Papers(9), textbooks(10), ASHRAE technical papers, etc.

THE BENEFITS OF CHP

The benefits of CHP can be summarised under the following headings:

1. Improved national energy efficiency and preservation of national energy resources.

2. Security of national energy supply.

3. Reduced dependence on imported fuels.

4. Reduced environmental pollution.

5. Improved balance of payments.

6. Cheapest heating (in conjunction with DH).

7. Ability to utilise low cost energy sources, i.e. refuse incineration.

8. Investment in British engineering, construction and service industry, skills.

9. More jobs (estimated at between 300,000 and 500,000).

The Marshall Report(7) estimated that, assuming 25%-35% of the existing domestic, commercial and institutional space heating and hot water service load was met by CHP, annual national energy savings could be achieved of 15-21 mtce and the Atkins Report(6) suggested a figure of 14 mtce. The extent to which these benefits will be realised is largely dependent upon the rate of development of large scale CHP city-wide schemes in th UK - a development commonplace in Europe, the USSR, USA and elsewhere.

THE ENERGY DEBATE and CHP in the UNITED KINGDOM

The national debate on energy policy is not a new phenomenon. Edward I decreed a reduction in coal burning and a return to wood burning in 1306 "to reduce pollution" and Edward III gave special protection to Gateshead Colliery owners and initiated coal exports to France; whilst in 1867 Jevons, in his book "The Coal Question", forecast a demand "well in excess of resources".

Keen and interested parties to the recent debate have been given a large quantity of

diverse and detailed information from an ever increasing number of sources - much of it conflicting! However, if we accept that a reasonably balanced view might be obtained from papers(11) offered by the Chairmen of BP, British Gas, UK Atomic Energy Authority, the Electricity Council, British Coal and the Consumer Council, then the situation could be summed up as follows:

(1) It is crucially important that we reduce our dependence on imported oil.

(2) Major economic recessions have been caused by recurrent oil crises.

(3) The economic implications of energy policy must be fully evaluated since practical alternative options must involve substantial expenditure and long term investment strategies are essential. Reliance on "market forces" is unwise.

(4) The "social dimension" is important. If energy is to meet the human need it should be consistent with other human requirements; efficiency, environmental factors, reliability, convenience and cost.

(5) Energy technology has been virtually revolutionised over the last two decades and continuing energy research is vital.

(6) A protracted timescale is involved in creating valid long term options.

Energy must be used more wisely; and coal with substantial reserves, and nuclear power could be expanded together.

In 1979, Energy paper 35(7) recommended, "in spite of the short term difficulties, that a

Combined Heat and Power District Heating strategy should now be drawn up and implemented". The Atkins Report(6) (1982) recommended that the "Government should encourage all energy and fuel supply industries to recognise the implications of the development of a CHP heat distribution industry and include this in their planning where appropriate". The Select Committee on Energy confirmed in 1983 12 their belief that, "CHP is the best of the options now when economics, comfort, fuel efficiency and long term environmental benefits are taken into account". The Prime Minister has an expressed interest in CHP with its, "clearly great potential for energy saving and job creation" and unequivocal support has been expressed by leaders of the Labour, Liberal and Social Democratic parties. The CEGB have confirmed their hope that, "after years of debate, the stage is at last set for actual progress on a national scale" and that the "introduction of CHP will be vigorously pursued". The Atkins Report 6 (first stage) confirmed the economic viability of city-wide CHP schemes in nine cities in the UK - Belfast, Edinburgh, Glasgow, Leicester, Liverpool, London, Manchester, Sheffield and Tyneside.

In April 1984 the Government initiated the second stage of the study and offered to contribute £750,000 towards further detailed studies in up to 3 of the cities listed. Applications were invited from local consortia for grants to prepare prospectuses and the Government insisted upon a need for substantial private sector participation and confirmed that future development would depend upon private sector finance. Subsequently 10 applications were submitted from which the Government selected 3 cities and confirmed the offer of grants of up to £250,000 each to Belfast, Edinburgh and Leicester. Prospectuses from

these 3 cities are under preparation and the submission of the Leicester study is imminent whilst Belfast and Edinburgh anticipate completion early in 1987. There are, however, 3 further detailed studies being undertaken, independently, by the cities of Sheffield, Newcastle and London and in Sheffield financial assistance has been received from the EEC.

Under the terms of the 1947 Electricity Act the ESI was required to investigate uses for the waste heat produced by conventional (steam) generating plant and the 1983 Energy Act requires the Area Boards "to adopt and support schemes for CHP and for the use of heat produced in combination with Electricity". The implications of Clause 19 of the 1983 Act were clearly defined by the then Under Secretary of State for Energy on the 28 March 1983: "Clause 19 gives Electricity Boards a new duty to promote economic schemes through combined heat and power and the use of power stations generally. This clarifies their rights and obligations in this field and puts beyond doubt that such schemes are to be considered part of the Board's normal operations".

However, an important factor presently delaying the widespread implementation of CHP is that of the Tariff Structure for electricity generated privately and sold to the Area Boards. It is the view of the Combined Heat and Power Association, and many others, that the basis on which such tariffs are calculated is not readily understandable and the CHPA Tariffs Forum continues to debate and clarify this matter.

A major factor affecting the economic viability of city-wide CHP/DH is that of the rating of such schemes by local Valuation Officers. Utilities are normally rated under a statutory

formula in the General Rate Act 1967, and under the terms of the Local Government Act, 1974 (Section 19). Utilities such as Electricity and Gas Boards are subject to rating "by order" and it was originally felt that in the absence of any formula relating directly to city-wide CHP/DH, valuation might be based on the "Contractor's Test Method" which might result in rates amounting to over 20% of the anticipated annual turnover, as opposed to the average 2.1% of actual turnover paid by the ESI. It has, however, now been agreed in principle that CHP/DH schemes should be valued for rating purposes by reference to the formula now applied to the ESI (suitably amended).

Government response to the Select Committee on Energy Report appears to have overlooked the major point implicit in paragraph 67, i.e. that Government should find ways "to arrange, assess and finance it (CHP/DH) on the same terms as the other public supply industries". The view has also been expressed that energy policy can best be dealt with by "market forces" but this simplistic approach suffers from the major defect that effective options to meet changing circumstances can only be provided as a result of long-term investment strategies(11).
The more recent report of the Select Committee on Energy on the EEO includes again the recommendation that a serious Government study needs to be undertaken into the current bias in favour of public sector investment in supply rather than demand management. The aim must be to begin to apply the same financial criteria to investment in these two areas. Publicity should be given to those investments offering the probability of the highest financial return and the lowest economic and technical risk.

Investment in public utilities is normally not attractive to the private sector since it is by

nature, long term, and it would be interesting to see the Sizewell 'B' project subjected to private sector investment analysis. The Combined Heat and Power Association believes that CHP schemes are placed at a serious and unfair disadvantage by the present Government requirement for dependence upon private sector finance. The perspective of Merchant Bankers(14) towards investment generally is conditioned by their own history and for CHP/DH investors large sums of money are involved, with extended payback periods (10 to 20 years) at relatively low rates of return. Industrial CHP schemes have, however, often met strictly commercial criteria of profitability.

In assessing CHP or CHP/DH schemes the Institutions require a detailed prospectus, including basic costs, revenue projections, margins of error, profitability and the planned corporate and capital structure. The recent Report by the Select Committee on Energy on the EEO is therefore of considerable importance as are their present investigations into the effects of the implementation of the 1983 Energy Act.

INSTITUTIONAL ARRANGEMENTS

It is considered that for CHP/DH to realise its full UK potential it will be necessary to adopt regional and local arrangements suited to the various cities/towns involved. Such arrangements will undoubtedly include representatives from industry and commerce as well as local or regional authorities - as is the case in Sheffield(15).

It is realised that such 'local arrangements' will, of necessity, bear resemblance to a 'common' structure, or framework. However, the structure would not consist of a uniform

formula to be imposed upon, or adopted by local consortia in their efforts to develop CHP/DH. Rather it would represent a common procedure to facilitate local development of CHP/DH by devolving responsibility to Local Authorities, Area Boards, etc.

PROGRESS IN EUROPE

OECD countries(16) generally rely upon a combination of market forces and government action to achieve balanced energy economies and present policies need to be strengthened to prevent energy costs and availability restraining future economic growth. One of the most significant common developments in CHP/DH in OECD member countries is that, independent of financial incentives and active central Government support, the main impetus comes from local levels. As in the UK, continental national and regional power utilities employ central decision-making, planning and financial controls and have available considerable low-cost and long term financial resources.

Only in a relatively small number of cases are national power utilities involved in CHP. Municipal/local utilities involved in production sell excess power to, or purchase power from, the national utility. With the exception of the UK and the USA, where the Government positions are neutral, the attitude of OECD Governments towards CHP/DH is generally positive, and differing degrees of financial assistance are provided.

Power to mandate CHP/DH exists in most countries and the potential of CHP for employment generation, security of supply, improved balance of payments, etc. is increasingly recognised. Individual Government perspectives on energy policy are of necessity

varied and include macro-economic aspects of industrial development, employment, exports, indigenous resources and balance of payments considerations. A difficulty in several countries is that of ensuring that regional or local implementation of CHP/DH is consistent with central Government aims.

The policies of the major utilities generally reflect Government national energy considerations and individual Government pricing and taxation policies determine to a very large extent the relative impacts of competing energy options. Utility attitudes to CHP/DH have tended to be somewhat negative, although this attitude is beginning to change favourably.

It is considered that the success of new District Heating developments will be determined by two criteria:

(a) that the consumer connection cost is reasonable, and

(b) that the heat price* and annual fixed charges are competitive with other options.

(*Combined heat and Power production can be a major factor in ensuring competitive heat prices).

In certain instances Governments may wish, in order to achieve national objectives, to provide financial assistance to offset very high initial capital outlays when revenue flows from connections are low, to assure the competitiveness of District heating over the long term.

IEA COUNTRIES

Total installed heat production capacity for DH

(district heating) in Europe is 82,000 MWth of which 29,500 MWth (36%) is represented by CHP. By the early 1990s, it is estimated that installed heat production capacity in Europe is likely to increase to 170,000 MWth (i.e. +109%).

In Denmark, Finland and Sweden CHP/DH development at national and municipal levels received active Government support and encouragement and CHP is a widely accepted and mature technology. In other European countries the rate of development has varied and in Austria and the Netherlands Governments have introduced major incentive programmes for CHP/DH. Again, in Germany, Government incentives have backed up an increasing impact for CHP/DH for reasons of energy conservation, oil substitution and the use of indigenous coal resources. Little development has taken place in Belgium, Ireland, Norway and the United Kingdom mainly due to natural gas pricing regimes.

In 1985 the President of the North American District Heating and Cooling Institute - Mr. Richard Eckfield - addressed a major meeting of several thousand members of the Mechanical Contractors Association of America. The main theme of his talk was simple but direct. The CHP/district heating market in the US is gathering momentum with a potential for an annual $4 billion opportunity for the installation of CHP/district heating and cooling systems. Already many universities, local utilities and hospitals are recognising the benefits of CHP/district heating, not only for themselves but also in the form of an expansion into the general communities. In his view everyone benefits from CHP/district heating:

the end user - with cheaper heat;
the utility - with lower costs, greater flexibility and higher profits;
the manufacturers/contractors - with a potential annual $4 billion market and its associated job creation;
the environment - with lower pollution of the atmosphere.

REDUCED ENVIRONMENTAL POLLUTION

The development of CHP/DH is generally acknowledged as having made a major contribution to the reduction of atmospheric pollution, and sulphur dioxide levels in particular. For example, the annual average sulphur dioxide level in central Helsinki (Finland) fell to one-sixth in the period of 1960 to 1980 and, although less dramatic, improvements have also occurred in other parts of the city. A reduction in the emission of sulphur to the atmosphere by some 2600 tonnes annually is seen as one of the major benefits arising from the Naantali-Turku district heating transmission system.

Danish Experience

Denmark has been particularly concerned regarding the interaction of their energy supply systems and the environment and current attitudes can be summarised as follows(17).

The Danish environment like all others is affected by the production and consumption of energy. Carbon dioxide (CO_2), steam and sulphur dioxide (SO_2), nitrogen oxides (NO_x) and various particles are emitted into the atmosphere when fuels such as coal and oil are burnt. However, the various types of fuel produce different mixtures and quantities of emissions exhausted to the atmosphere.

Coal and oil have a normal sulphur content of between 0.5 and 5%, most of which is transformed to SO_2 during combustion. The emission of NO_x into the atmosphere is due to oxidation of the nitrogen in the fuel and the combustion air. Besides NO_x and SO_2, particles (soot, ash, trace elements, etc.) are emitted together with exhaust gases and portions of these emissions may be reduced by means of equipment for exhaust gas purification. In the atmosphere, SO_2 and NO_x are transformed into sulphur and nitrogen, partly in the form of sulphuric acid and nitric acid, partly in the form of salts. The transformation rate depends on many factors such as light intensity, humidity and the concentration of different types of pollution and the presence of catalysts.

Danish engineers and environmentalists are particularly concerned regarding the adverse ecological effects to the environment, soil and vegetation, etc., resultant from the emission of such pollutants to the atmosphere and they are aware of the long term adverse effects on building fabrics also. It is understood that in addition to the specific fuel involved in combustion the degree of pollution depends both upon the combustion efficiency and on the plant employed for the purposes of combustion. Generally, it is felt that the conversion from individual heating systems into a collective i.e. CHP/DH supply system will result in a reduction of pollution generally since central plants can be operated at higher average efficiencies. Additionally, and possibly more importantly, large scale central plants such as CHP/DH systems can more easily absorb the additional investment required in more effective systems for the reduction of pollution. Table 3 demonstrates an example of

the environmental consequences resulting from the conversion of the individual systems to CHP/DH based on a city of 100,000 inhabitants with a total annual heat demand of 2500 TJ (695,000 MWth annual), half of which is served by individual coal fired systems and the remainder by individual gas oil fired heating systems.

The example demonstrates the calculated effects resultant from the penetration of CHP/DH systems at three levels, e.g. 40%, 60% and 80% of the total city heat demand. Seasonal efficiencies are estimated as being 50% for individual solid fuel systems, 65% for individual gas oil systems and 80% for CHP/DH systems. The table indicates that the conversion from individual systems to CHP/DH results in a reduction in sulphur and nitrogen oxide emission of between 18% and 37% and a reduction in particulate emission of between 37% and 75%.

It is appreciated that a proportion of this reduction is due to the reduced fuel burn but it is felt that the provision of more effective flue gas cleaning systems would undoubtedly improve the SO_2 and NO_x reduction figures. It is also appreciated that the environmental impact of air pollution depends upon other factors including the location of the heat producing plants, the height of chimneys, the combustion efficiency, type of fuel and prevailing meteorological conditions.

In addition to air pollution the use of energy affects the environment in other ways including pollution of water supplies, noise pollution, the production of wastes in the form of sludge and ash, and the introduction of heavy vehicular traffic. These other impacts can be reduced by the introduction of central CHP/DH

systems and the noise and traffic nuisance of fuel transportation lorries can be reduced by carefully selecting the location of the CHP/DH plant. Furthermore the establishment of a CHP/DH scheme allows for the introduction of a more rational municipal waste handling facility with consequent beneficial effects.

Refuse Incineration and Legislation in Denmark

A typical example of municipal refuse incineration is the Vestforbraending incineration plant in Denmark, the construction of which commenced in 1967 with completion in 1970. Twelve Danish local authorities pooled their resources to produce a system which they felt would treat waste professionally by incineration and compaction. It is considered these objectives have been achieved and the 2 million m^3 of waste brought to the Vestforbraending plant has been incinerated to approximately 5% of its original volume. The volume of waste received has increased by between 5 and 7% per annum mainly due to the closure of a number of landfill sites. The plant is provided with a 150 m high chimney complying with environmental codes and conditions laid down for recreational areas. The complex receives waste from a population catchment area of approximately 600,000 residents, i.e. approximately 1/9th of the country's total population and on an annual basis incoming waste totals some 320,000 tonnes.

During its initial 2 years of operation Vestforbraending operated as a waste disposal plant but on completion of a large regional hospital at Herlev some 4 km from Vestforbraending investment was made in a distribution network for conveying the waste

heat recovered during the incineration process. The network has subsequently expanded to a point where approximately 66% of the heat produced from the waste materials is now fully exploited and any shortfall in energy availability from waste is made good by means of an on-site gas/oil fired boiler plant. The DH distribution system is approximately 9 km long (high temperature) and 14 km long (medium temperature). The scheme is currently being re-arranged both to supply heat to, and receive heat from, the currently extended Copenhagen CTR CHP/DH system.

Impending legislation in Denmark covering incineration plants will include the following requirements.

(a) Materials for incineration will have to be pre-sorted/separated into the various categories, e.g. pvc, pesticides, heavy metal, contaminated waste, bulky materials.

(b) Continuous operation shall be employed with a minimum number of on and off operations when the possibility of contaminant release is greatest.

(c) The requirement to reduce dioxin formation:

CO levels maximum 100 mg/m^3N* - daily average
maximum 350 mg/m^3N - 10 minute period
maximum 800 mg/m^3N - 1 minute period

*(N = m @ O C & 1 bar)
Excess air minimum 6% O_2 and maximum 12% O_2

Retention time in secondary burning zone - 2 secs at 875°C minimum.

Turbulence requirements in secondary burning zone - Re > 60.000

Operational temperatures - running 950°C

and maximum 1200°C

Oil burner < 870°C

Preheating of the combustion air

The provision of oil burners having a minimum capacity equal to 50% of the plant capacity

(d) Pollution control shall include flue gas cleaning.

Electrostatic precipitators to reduce particle emission to < 40 mg/m^3N at 10% O_2.

Reactive cleaning equipment to remove gas contaminants to specific levels for the following:

hydrochloric acid, cadmium, lead, mercury, hydrogen fluoride, sulphur dioxide, TOC, etc.

(e) Chimney. Chimney heights will be required to relate to plant capacities as follows:

<50,000 tonnes / year	75 m
100,000 tonnes / year	100 m
200,000 tonnes / year	125 m
300,000 tonnes / year	150 m

(f) Operational Controls. Constant monitoring and measurement of the following parameters will be required:

opacity/particles - after flue gas cleaning;

hydrochloric element - after flue gas cleaning;

O_2/CO_2 - after boiler;

CO - after boiler;

temperature (4 places) - furnace, secondary burning zone, after boiler and chimney

(g) Automatic Control. This will be required of the following:

air supply
air distribution
variable "grid speed".

It is felt that the cost of flue gas cleaning equipment utilising the acid bath process would result in investment equivalent to approximately 30% to 33% of the total plant cost. It is appreciated that dry cleaning techniques cost less and whilst it may be felt that the wet cleaning system is most proficient with an approximate 10% to 50% higher capital cost in certain instances, the dry cleaning facility may well meet the required regulations.

The UK Experience

Whilst the United Kingdom has not been motivated to the same extent as the Scandinavian countries with regard to the possible need to reduce environmental pollutants, there is no doubt that a considerable amount of work has been carried out, and is continuing to take place, into possible methods for reducing the release of contaminants into the atmosphere. Consideration of the important part which indigenous solid fuel must play in our future energy policies in the United Kingdom must include reference to the need to ensure that the release of pollutants is restricted to an acceptable

level.

In a paper presented on 7 October 1985 at the Royal Institution, London, the Research Director of the CEGB Central Electricity Research Laboratories, Leatherhead, Mr. P.F. Chester, summarised the relationship between "Coal and our Atmosphere" in the 1985 Robens Coal Science Lecture. Detailed reference is made in the paper to the environmental effects of the combustion of coal and to the relatively new technology of flue gas desulphurization (fgd).

The disposal of waste products from flue gas desulphurization is considered to be "not a trivial matter" and considerable research and development is in progress into alternative methods, possibly employing the injection of ammonia into the flue gas and the bombardment of this mixture with electrons. There are also systems under development which inject powdered lime into the gas stream which is then captured on a fabric filter and reacts there to capture additional sulphur dioxide. Additionally, research is taking place into the method by which sulphur can be removed from coal before combustion.

Also of interest is the possible application of pressurized fluid bed combustion technology since this may well provide a cheaper alternative to flue gas desulphurization.

The Government has also recently announced the expenditure of £600 million on the provision of flue gas cleaning equipment in three major power stations in this country. There is undoubtedly therefore an atmosphere of increasing awareness of the adverse effects of indiscriminate release of pollutants to the atmosphere, particularly from large solid fuel

fired power generation plants and there is no doubt that the more widespread implications of CHP/DH, possibly together with municipal refuse incineration, would considerably reduce the emission of pollutants to the atmosphere from alternative individual solid fuel/oil fired systems in not only the domestic but also the industrial field.

ALTERNATIVE ENERGY RESOURCES

The Government has confirmed that it has abandoned its investment in wave power and that at present hydro-electric power contributes some 2 mtce to the total United Kingdom energy supply. Forecasts for renewable energy contributions to total supply in the year 2025 were contained in ETSU R30, which indicated that heat producing technologies and electricity producing technologies would contribute some 26 mtce and 2 mtce respectively.

CONCLUSION

The benefits of CHP/DH are widely recognised in most IEA member countries .
CHP/DH has been described as a "hedge technology" to reduce the adverse effects of oil supply disruption and to increase fuel flexibility.

Long term Government reasons for providing financial assistance are based upon:

- energy conservation
- oil substitution and fuel flexibility
- maximisation of indigenous energy resources
- environmental quality level improvements
- increased employment
- improved balance of payments
- use of low grade, negative cost, heat

sources, e.g. refuse incineration and industrial waste heat.

CHP/DH development is a complex process requiring long term planning and in most European countries there exists a highly developed system of devolved responsibility for electricity generation and heat production down to regional and municipal levels but this does not exist in the United Kingdom.

A study of existing Continental legislative frameworks indicates a marked difference from that of the UK in that a significantly higher degree of autonomy is evident on a regional or municipal basis.

Local needs are accordingly taken into account, subject to Government approval of regional heat plans, and regional/municipal authorities enter into arrangements with private/commercial investors to plan, implement and operate local schemes; such arrangements varying dependent upon local conditions and levels of Government support.

The major benefits of the implementation of CHP/DH and industrial CHP to the United Kingdom have been clearly demonstrated and Government has a clear duty to formulate an energy strategy, or policy, in national terms, if we are to achieve the levels of energy efficiency expounded by the Secretary of State for Energy, Mr. Peter Walker.

Energy Efficiency Year and "Monergy 86" can be the springboard from which the United Kingdom can break loose from the legislative and economic frameworks which effectively inhibit progress in national terms - the ability, the technology, the skills, and the finance are available, only the national 'will' is missing.

The Government has confirmed its commitment to national energy conservation - we must wait to see if words are translated into effective action. CHP has a proven and universally accepted potential to contribute, in massive terms, to the preservation and more efficient utilisation of our national energy resources.

It would seem unwise to ignore its potential for the United Kingdom when we observe the increasing importance attached to CHP by our fellow European partners and the IEA member countries.

REFERENCES

1. Digest of UK Energy Statistics 1985 HMSO (Department of Energy) Table 1 (312.9 mtce).
2. Digest of UK Energy Statistics 1985 HMSO (Department of Energy) Table 5.
3. Energy Flow Chart 1983 (United Kingdom) Department of Energy issued June 1984.
4. "The Future Uses of Gas" Dr. E. Clatworthy, PH.D. B.Sc., Director, Industrial & Commercial Gas, British Gas Corporation. (Paper presented at National Conference, CHPA, June 1985).
5. Digest of UK Energy Statistics 1985 (Table 57).
6. CHP/DH Feasibility Programme - Stage 1, WS Atkins & Partners. July 1982.
7. Combined Heat and Electrical Power Generation in the United Kingdom. Energy Paper 35 HMSO 1979.
8. "Combined Heat and Power - the Co-generation Game"
Roger Dettmer - Electronics & Power - October 1985.
9. "Plant Options for CHP - an introduction

and guide" by A.F. Postlethwaite, B.Sc, C.Eng. MI. Mech.E. (CEGB) CHPA Technical Paper No. 10.
"The use of Gas Turbines for CHP/DH" by P. Bonham, Principal Applications Engineer, Ruston Gas Turbines. CHPA Technical Paper No. 9.
"Small Scale CHP" by I. Dudley, C.Eng. M.I.Gas.E. Northwest Region, British Gas.

10. "District Heating - Thermal Generation and Distribution" by C. MacKenzie-Kennedy (Pergamon Press 1979).
11. "The Energy Debate" - Benn Technical Books 1983. Contributors:
Sir David Steel, Chairman, British Petroleum Company
Sir Derek Ezra, Chairman, NCB. Sir Dennis Rooke, Chairman, British Gas
Sir John Hill, Chairman UKEA, Sir Hermann Bondi, Dr. Anthony Challis, et al.
12. House of Commons Select Committee on Energy, 3rd Report, 1983.
13. "Electricity Tariffs and the 1983 Energy Act", B. Wilkins, A.Eng, Senior Partner, PMA.
(Paper presented at CHPA National Conference, June 1985).
14. "Provision of Finance - A Merchant Banker's View" by M.J.N. Barnett, Assistant Director, Kleinwort Benson Ltd.
(Paper presented at CHPA National Conference, June 1985).
15. "Institutional Arrangements" CHPA Parliamentary & Local Government Committee Paper (1984).
16. "District Heating and Combined Heat and Power Systems - a technology review" 1984 OECD.
17. "Environment & Energy" Ramboll & Hanneman 1986.

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The information extracted clearly demonstrates a long established and increasing European commitment to CHP.

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PLANNING, ENTERPRISE ZONES AND "LIFTING THE BURDEN"

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INTRODUCTION

The extent to which land use planning may be used as a means of maintaining or improving environmental quality needs to be reassessed in the light of radical changes in central government policy in the 1980s. The level of regulation and intervention previously exercised by both central and local government departments is seen as incompatible with the fundamental commitment to a monetarist economic strategy and an individualistic political ideology.

Statutory controls under the town and country planning system must be listed among those 'administrative and legislative burdens which take time, energy and resources from fundamental business activity' (Cmnd 9571, 1985, p.1). Whilst abolition of a planning system which since 1947 'has served the country well' is not contemplated, simplification and improved efficiency are required to minimize the imposition of 'costs on the economy and constraints on enterprise that are not always justified by any real public benefit in the individual case' (op.cit., p.10).

Hitherto, the programme of deregulation has resulted in a small number of relatively minor amendments of planning legislation. Nevertheless, the central government's resolve not to allow planning to impede industrial regeneration, especially with regard to small firms, is plainly apparent from the content of various recent white papers and DOE circulars. This subordination of the planning process to the pursuit of economic policy objectives has important implications for those in local government who see planning powers as a means of supplementing their controls over pollution.

A consideration of these implications forms the main focus of this paper.

THE CENTRAL GOVERNMENT VIEW

The view of central government may be summarised thus: an over-rigorous application of a local planning authority's discretionary powers can impose unnecessary impediments to industrial and commercial enterprise, especially for small firms. In various publications, advice is offered to local planning authorities on certain changes in approach to the exercise of their development control powers which, it is claimed, would ensure that these powers are applied so as to maximize social and economic benefit.

(i) In DOE Circular 14/85, local planning authorities are reminded that any development plan policy is but one among other 'material considerations' to be taken into account in deciding planning applications. Development plans should not be seen as 'overriding' since 'they cannot be adapted rapidly to changing conditions and they cannot be expected to anticipate every need or opportunity for economic development that may arise' (DOE Circular 14/85, p.1).

(ii) DOE Circular 1/85 reiterates advice given in the now superseded MHLG Circular 5/68 on the avoidance of planning conditions which, inter alia, duplicate controls available under other legislation. Such conditions are seen as unreasonable, especially when they conflict with other statutory requirements on a developer. In the past, the Industrial Air Pollution Inspectorate has been particularly outspoken in its hostility towards

planning conditions which relate to atmospheric emissions from scheduled works (Miller, 1983). It is interesting therefore, that this circular makes no explicit reference to conditions which seek to impose controls over air pollution. However, a number of model conditions referring to noise, both in terms of emission and immission, are included: specifying the necessary sound attenuation which the construction of a building must offer; suggesting boundary noise limits from industrial sources; restricting hours of take-off and landing at aerodromes; and requiring proposals for residential development to include a scheme outlining internal and external means of mitigating the effects of traffic noise. This latest advice is consistent with that given in DOE Circular 10/73; and noise therefore retains its somewhat anomalous position as the form of pollution for which direct control by planning conditions, albeit suitably worded and only in appropriate circumstances, is encouraged by the Department of the Environment.

(iii) "Lifting the Burden" (Cmnd 9571) stresses the government's desire to see a planning system which works 'eficiently and effectively' and which minimizes delays and costs to business entrepreneurs, especially the self-employed and small firms.
A number of specific measures are proposed by which certain development can be undertaken without the need for explicit planning approval.

(a) The enterprise zone concept is to be extended to 'simplified planning

zones' wherein specified types of development are exempted from the need to secure local planning authority approval.

(b) Amendment of the General Development Order will extend the range of 'permitted development', particularly by raising permitted limits on extensions to industrial buildings and warehouses.

(c) Within a revised Use Classes Order, a new 'business use class' will allow changes of use between the existing office and light industrial use classes. Also, it is planned to expand 'the special industrial groups' which currently include the most potentially polluting uses such as animal rendering works, metal and mineral processing and those works which come under the jurisdiction of the Industrial Air Pollution Inspectorate.

The third of the above measures, revision of the Use Classes Order, is perhaps the most significant in terms of its implications for the environment. Despite the government's acceptance of the need to retain 'effective control over changes of use which, because of their environmental consequences or relationship with other uses, need to be subject to specific control' (Cmnd 9794, p.22), it can be safely assumed that the local authorities will be anxious to ensure that their views are heard before any changes to the Use Classes Order become law.

THE VIEW OF LOCAL GOVERNMENT

The relations between central and local government have been dominated in recent years by economic issues. The effects on the public sector of the government's tight control of money supply have been vigorously denounced by numerous county and district councils, especially those representing the conurbations and the older industrial centres. The disqualification of councillors in some of the rate-capped authorities and the total abolition of a tier of local government in the metropolitan areas are powerful reminders of the reality of the relationship between local and central government within our constitution. Any discussion of the view of local government towards the deregulation proposals must inevitably be set in this context.

It would be grossly mistaken to assume that the underlyhing aims of "Lifting the Burden" are automatically dismissed by local authorities, even those most politically opposed to the present government. On the contrary, the local bodies are no less anxious to remove obstacles to job-creating activity within their area. Many might justifiably claim to have been exercising their discretionary planning powers in this spirit for some time. Many can demonstrate, contrary to the claims of DOE Circular 14/85, that their structure and local plans have fully recognised and catered for the land use needs of industrial (especially high technology) regeneration; and within the areas so allocated, planning consent has become merely a formality. With so many urban local authorities vocally resentful of the success of the New Towns and the Urban Development Corporations in attracting entrepreneurial activity, it is hard to believe that they would enforce the existing controls in as dogmatic and inefficient a manner as the White Paper implies. Local authority apprehension of

deregulation stems not so much from opposition to any particular modificiation of the legislation hitherto promulgated but more from a suspicion that they signal a more fundamental dismantling of the planning framework and a further shift towards centralisation.

A local authority might argue that whilst it accepts that assisting job-creation is its first priority, this cannot be at the expense of its responsibility to maintain the quality of the local environment. Despite the recession, the numbers of complaints to local authorities about noise, from industrial and not simply from domestic sources, continue to rise (DOE 1986, p.9). And while the Royal Commission on Environmental Pollution (1984, p.172) postulated that a general lowering of environmental quality might be tolerated by the general public if this led to lower unemployment, they concluded that the available evidence did not support this conjecture. The recent series of environmental disasters abroad - Seveso, Bhopal and Chernobyl - has served to heighten public expectation of a risk free environment. Irrespective of the rationality of public fears over relatively innocuous materials, and notwithstanding the losses to a local economy that the prevalent NIMBY ('not in my back yard") principle can entail, the environmental factor cannot be excluded from the local political agenda.

It therefore remains legitimate for a planning authority to withhold planning consent for any hazardous or polluting development if it is not satisfied that adequate powers exist to ensure what it, the authority, judges to be an acceptable level of hazard or pollution. A local authority's statutory powers to intervene on behalf of the environment are far short of universal; and this has led to the use of

planning controls, particularly planning conditions and agreements, to supplement public health and pollution legislation. According to the Department of the Environment (Cmnd 9794, p.27), a strengthening of statutory nuisance law might lead to a reduction in what it describes as the 'unnecessary imposition of planning conditions'. The crucial issue is that planning conditions are anticipatory in effect and can be used to prevent pollution and nuisance arising; in contrast, statutory nuisance is retrospective in effect: action can be taken only after nuisance has been demonstrated.

This shortcoming of the legislation was commented upon by the Royal Commission on Environmental Pollution (1976, p.30); but the government's belated response (DOE, 1982) did not address this particular issue. In its tenth report, the Royal Commission (1984, p.56) again referred to this question, noting the representations made to it by the National Society for Clean Air, the Institution of Environmental Health Officers and the Association of District Councils. If, following the 'comprehensive review of air pollution control legislation' (DOE, 1982, p.7) currently being undertaken by the Department of the Environment, local authorities continue to lack anticipatory controls over non-scheduled, non-combustion sources of pollution, then resort to the use of planning conditions or agreements can hardly be described as unnecessary.

The Royal Commission (1976, p.99) also expressed its concern over the increase in pollution which could follow an increase or change of use of a building within a particular use class. It recommended that such a change should not, as current legislation specifies,

necessarily be exempt from planning control. In response, the Department of the Environment considered that planning intervention in such circumstances 'would not be appropriate' (DOE, 1982, p.16). It comes as no surprise therefore to note that no reference is made to this question in the recent consultative paper on the proposed revision of the Use Classes Order (Property Advisory Group, 1986). This paper envisages no alteration of the existing 'general industrial class'. However, it is possible to cite instances (Miller, 1983) of anomalies arising from changes of use within this class of industrial building: a building previously used in rug manufacture was taken over by a company engaged in chemical formulation and packaging; considerable pollution and nuisance was caused by herbicidal chemicals released to adjacent areas, but since the processes did not come within the jurisdiction of the Alkali Inspectorate (as it then was) this change came about without planning intervention, notwithstanding the environmental threat it posed.

However, the planning control of 'hazardous', as distinct from polluting, development would appear to be viewed with less ambivalence by the Department of the Environment. Far from diminishing the opportunities for intervention, both the General Development Order and the Use Classes Order have been amended to exclude changes and intensification of use involving 'the manufacture, processing, keeping or use' of notifiable quantities of certain hazardous substances from 'permitted development'. And following the advice of the Advisory Committee on Major Hazards (Health & Safety Commission, 1984, p.24), the relevant section (s.165) of the Town and Country Planning Act 1971 has been amended so as to reduce a planning authority's liability to pay compensation for the loss of

permitted development rights in such circumstances.

It might be argued that the overall environmental damage threatened by hazardous substances is so much greater than that associated with those which can only be described as polluting (these terms are, of course, not mutually exclusive) that these more stringent planning controls are justified. Alternatively, one may attribute this apparent difference in the perception of the applicability of planning powers to the influence of the European Commission (see below) and to a political awareness of the public reaction to the Seveso catastrophe and similar incidents at home and abroad.

THE ROLE OF THE COURTS

Attention hitherto has been concentrated upon differences between central and local government's perceptions of the relevance of planning in the control of pollution. It is necessary to broaden this discussion to include the role of the courts in interpreting the statutory powers of local planning authorities insofar as they relate to environmental pollution.

One recent case in the High Court (London Borough of Newham v Secretary of State for the Environment and East London Housing Association) is particularly germane (ENDS Report 134, March 1986). A housing association had appealed against a refusal of planning permission to convert a number of houses into flats; at the ensuing public enquiry, the planning authority urged the Secretary of State to apply conditions requiring adequate sound insulation if he chose to allow the appeal. In upholding the appeal, the Inspector argued that

sound insulation was not a planning matter and that noise complaints could be dealt with under Part III of the Control of Pollution Act 1974. The planning authority took this decision to the High Court. Here, Mr Justice Webster, in reversing the Inspector's decision, cited para. 19 of DOE Circular 1/85 as being relevant in this case: planning conditions might be justified 'where they can prevent development being carried out in a manner which would be likely to give rise to onerous requirements under other powers at a later stage'. Since the sound insulation provisions of the Building Regulations 1985 are not readily applicable to flat conversions, planning conditions are the only means available to a local authority to prevent this form of nuisance before it arises. Since the ruling in the case is contrary to the spirit of the latest White Paper (Cmnd 9794), it will be of some interest to practising planners.

In another recent case, (W T Lamb Properties v Secretary of State for the Environment and Crawley Borough Council, JEPL, May 1983, 303), the High Court again delivered a decision which could subsequently assist planning authorities to prevent incremental degradation of their local environment. This case is particularly germane to the present discussion since it concerned a proposal to convert a warehouse to the manufacture of gauged brick arches. If this latter use was such that the building was, as the developers argued, a 'light industrial building', then, following the amendment of the General Development Order in 1981, this change of use was permitted without the need for planning consent. Since background noise from the nearby Gatwick Airport was considerable (with peak levels of 86 dB(A) recorded within the building), it might be argued that any noise from brick manufacture would make

negligible impact on the amenity of an area already so blighted by noise, and that the designation of 'light industrial building' could apply. This view was rejected by the planning authority and, it must be stated, by the Secretary of State. In concurring, Mr Justice McCullogh held that it was necessary to consider the effect of the proposed change of use, not on the actual locality, but as the statutory instrument specifies, on "any residential area".

There is an obvious danger in drawing too many inferences from individual cases such as these. But it must be remembered that over the last forty years, town and country planning has acquired a considerable body of legislation with copious volumes of related case law. And while a desire on the part of central government to see a more fundamental revision in the planning system may be detected, the deregulation programme has actually resulted hitherto in only minor legislative changes. The judiciary remains therefore the interpreter and guardian of a body of law developed largely in a period when the prevailing consensus politics favoured a more balanced competition between the interests of economy and environment.

THE SUPRA-NATIONAL ORGANISATIONS

If the United Kingdom judiciary constitutes a third, independent element to be considered in any discussion of the role of planning in the management of the environment, then another source of rapidly growing influence is the European Commission. Reference was made earlier to EEC Directive 82/501 (the so-called 'Seveso' directive) and its effect on UK controls over hazardous installations. Many of the issues raised in this paper would be made

redundant were 'environmental impact assessment' to be fully integrated into the development control system. But largely as a result of British intransigence, the directive (EEC Directive 85/337) finally adopted is a pale imitation of earlier drafts, and EIA will be mandatory only for major projects.

Nevertheless, there are aspects of European environment policy which are of relevance to the smaller scale developments which occupy the greater part of local authority planners' time. The principle that pollution and nuisance should be prevented at source is one of the main elements of the European Community's Third Action Programme on the Environment (OJEC C46. 1-16, 17 February 1983). Moreover 'anticipate and prevent' strategies as distinct from 'react and cure' were also advocated at a recent conference of the member states of the Organisation for Economic Co-operation and Development (OECD, 1985). The UK government's continued belief in the efficacy of its statutory nuisance powers could be interpreted as being at odds with the policy aims of these supra-national bodies.

But perhaps the most important element of the Community's Third Action Programme is its call for the inclusion of an environmental awareness within all community policies (agriculture, fisheries, transport, energy, etc.) rather than attempting to pursue an environmental policy in isolation. If UK environment and land use policies are to be integrated in the sense implied by the European Commission, then there should be a far more explicit recognition of pollution, both in terms of emission and immission, as a 'material consideration' to be taken into account not only in the control of development but also in the formulation of development plans. The tenor of recent white

papers and circulars is such as to suggest that such a declaration by the central department is unlikely to be forthcoming.

CONCLUSIONS

In terms of immediate political significance, the issues raised in this paper are indeed lightweight when compared with, for example, the vexed question of the selection of sites for the disposal of low and intermediate level radioactive waste. The recent disaster at Chernobyl has undeniably placed the whole nuclear question among the foremost issues on the national political agenda. Britain's refusal to join the '30% Club' and its continued opposition to the draft directive seeking reductions in the sulphur emissions from large combustion plant are of considerably greater international importance than any particular failure to observe the spirit of the Third Community Action Programme.

But if the continued absence of effective prior controls over sources of pollution which lie outside the scope of the Clean Air Acts as well as the Alkali Act is not of primary importance, it is not insignificant. The majority of such sources may be small scale; but they are numerous and collectively they account for a sizeable contribution to the national burden of disamenity and environmental degradation.

From recent government publications and ministerial speeches, it is possible to detect the emergence of what amounts to a two-tier system of planning control. A small number of major projects would be subject to environmental impact assessment, which would be submitted to detailed scrutiny at a full public inquiry. Probabilistic risk assessment, such as that employed in the Canvey Island study

(Health and Safety Executive, 1978) will become increasingly standard for developments involving chemical or radiological hazard. And we can expect to see further resort to the use of special development orders as a device for enabling parliamentary debate on planning decisions taken at ministerial level. Outside these exceptional developments, the environmental implications of which cannot be overlooked, there would appear to be a trend towards reducing planning intervention (to the point of abolition for certain categories of development in enterprise zones and similar areas).

Many would argue that the exigencies of the economic recession do indeed merit a relaxation of environmental regulation, both in terms of planning and pollution controls. The Royal Commission on Environmental Pollution (1984, p. 172) takes a different view:

> 'Such an approach is short-sighted ... Any industry treated in this way is effectively being subsidised by environmental neglect.'

The evidence presented to the Royal Commission failed to cite instances of plant closure which could be directly attributed to the effect of environmental controls. Moreover, the Royal Commission stresses the positive economic benefits which can result from pressures to reduce pollution. Recent studies (Royston, 1979) indicate the extent to which 'pollution prevention pays' by avoiding the waste of raw materials and energy which unimaginative discharges to the environment often entails. The ethos underlying "Lifting the Burden", however, is a reflection of what the Royal Commission recognises as a 'decreasing emphasis on environmental protection in the United

Kingdom' (RCEP, 1984, p.190).

Despite the advice of central government, both the environmental and the economic case for local authorities to relax their vigilance have yet to be demonstrated.

REFERENCES

Command 9571 (1985), Lifting the Burden, HMSO, London.
Command 9794 (1986), Building Businesses ... Not Barriers, HMSO, London.
Department of the Environment (1973), Planning and Noise, Circular 10/73, HMSO, London.
Department of the Environment (1982), Air Pollution Control: Pollution Paper No. 18, HMSO, London.
Department of the Environment (1985), The Use of Conditions in Planning Permissions: Circular No. 1/85, HMSO, London.
Department of the Environment (1985), Development and Employment: Circular No.14/85, HMSO, London.
Department of the Environment (1986), Digest of Environmental Protection and Water Statistics No.8 1985, HMSO, London.
Health and Safety Commission (1984), The Control of Major Hazards: Third Report of the Advisory Committee on Major Hazards, HMSO, London.
Health and Safety Executive (1978), Canvey - an investigation of potential hazards from operations in the Canvey Island/Thurrock area, HMSO, London.
Miller, C.E. and Wood, C.M. (1983), Planning and Pollution, Oxford University Press, Oxford.
Ministry of Housing and Local Government (1968), The Use of Conditions in Planning Permissions: Circular No.5/68, HMSO, London.
OECD (1985), Environment and Economics, Organisation for Economic Co-operation and

Development, Paris.
Property Advisory Group (1986), Town and Country Planning (Use Classes) Order 1972, DOE, London.
Royal Commission on Environmental Pollution (1976), Fifth Report - Air Pollution Control: An Integrated Approach, Cmnd 6371, HMSO, London.
Royal Commission on Environmental Pollution (1984), Tenth Report: Tackling Pollution - Experience and Prospects, Cmnd 9149, HMSO, London.
Royston, M.G. (1979), Pollution Prevention Pays, Pergamon Press, London.

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AIR POLLUTION AND THE DIESEL ENGINE

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INTRODUCTION

The diesel engine has a world wide and broad range of applications exceeding that of any other engine. It will be found driving vehicles and power units in polar and tropical desert situations. Small boats to large ships including airships are propelled by diesel engines and submarines have not long abandoned such a power unit. On farms and small-holdings, tractors and machinery of all kinds use diesel power and so do the many civil engineering vehicles as well as railway locomotives. For land stationary duty requiring power for pumping and electricity generation, from one or two horsepower to many hundred, they will be performing very reliably. On the road they can be seen expanding their field of application from the juggernaut to the small private vehicle.

Yet the diesel image has not the acclaim of the petrol and gas turbine engine; even the old steam engine seems to evoke greater respect and veneration as it retires to the museums and demonstrates its ability only at prestigious events where it will huff and puff up and down specially vacated railway tracks.

Since the diesel engine does so much to serve man's ambitions it is worth examining those characteristics, particularly if they are environmental, which debase it relative to its more favoured rivals. The diesel engine, both with respect to its fuel and exhaust, has a smell and a characteristic noise but neither of these factors could be compared unfavourably with the steam engine. However, such a comparison is probably no longer valid since the steam engine grew up in a different age when noise, smell and smoke symbolised power

and productivity. That age, whilst still venerated with some degree of nostalgia, has been superseded and it might seem that the respect that once existed for the characteristics which went with heavy engineering never really got associated with the diesel engine. Despite its reliability and economy it might seem that emotionally inspired sentiments sway the public mind against the diesel engine. The objectivity of the NSCA should be exercised to try and assess what roles that engine is most suited to serve and what efforts should be made to correct undesirable features in the performance of those roles.

A REVIEW OF THE POLLUTANTS FROM DIESEL ENGINES

Hydrocarbons

The diesel engine, unlike the petrol engine, effects the ignition of its fuel by subjecting air, into which fuel is injected, to very high pressures. Such pressure raises the temperature sufficiently for the fuel to auto-ignite. Although hot glow plugs may be used to give initial start-up ignition in some engines, no subsequent aid is needed to keep the engine firing. On this account the degree of compression has to be somewhat higher than in petrol engines; consequently, a more robust and therefore heavier structure is necessary. It is also necessary to use a fuel which will ignite spontaneously at the pressures and temperatures which it is feasible to achieve. Petroleum fuels, which comprise hydrocarbons will, as a broad generalisation, ignite more readily if those hydrocarbons are heavier and contain a higher carbon content. It is also true that more carbonaceous hydrocarbons have greater molecular weight and are less volatile. As it is necessary for liquids to vaporise before they can take part in combustion it is

apparent that there must be a compromise between the conflicting characteristics of low spontaneous ignition temperature and volatility. The petroleum distillate comprising hydrocarbons in the boiling range 200° -360° C has been adopted for most diesel applications. Variations from this and within this distillation range may, however, be better for one or other particular engine design. But at this stage, keeping to generalisations, it must be postulated that because diesel fuels have a higher carbon content than petrols they will have a greater tendency to produce smoke.

In the operation of the diesel engine, fuel starts to be injected near the end of the compression stroke and ceases some 10 degrees or so of crank angle after the top dead centre of the piston stroke. The lower the auto-ignition temperature or slower the engine speed, the earlier in the piston movement cycle will combustion start to take place. Early auto-ignition will promote smooth combustion. Conversely, if auto-ignition is late in the cycle combustion will be more explosive and noisy.

It is common knowledge that sulphur is indigenous to petroleum crude oil and exists in a range of compounds with hydrocarbon radicals which are more prevalent in the higher molecular weight, less volatile components. Hence sulphur is present to significant degrees in the distillates comprising diesel fuel but insignificant in the distillates used as petrol. A normal diesel distillate will contain 0.5% or more of sulphur but this will be reduced to 0.3% or lower by a desulphurising process.

Gaseous emissions

As with petrol engines, the gaseous products of incomplete as well as complete combustion are emitted. The greatest difference is that carbon monoxide emissions are generally less from diesels because the controlled injection of fuels allows the engine to be operated at fuel/air mixtures weaker than stoichiometric. Because combustion efficiency is a little better and fuel/air mixtures weaker than stoichiometric, control of oxides of nitrogen (NOx) presents a greater problem than control of carbon monoxide. However, little attention has been paid to the control of either pollutant from small diesel vehicles in Europe. Indeed it is a matter of some dismay that modifications of the 04 amendment to the EEC regulation 15, whereby nitrogen oxides (NOx) and hydrocarbon emission limits were combined to make it easier for diesel engines to comply, has not been applied to diesel vehicles. Neither is there any adoption of regulation 49 covering gaseous emissions from non-passenger car type vehicles in the UK. Recent proposals for a revision of EEC directive 70/220/EEC ("Measures against air pollution by gases from engines of motor vehicles") and a new directive ("Measures against gaseous pollutants from diesel engines for use in vehicles"), if approved, should bring about some control in the UK but not before the early 90s (15), (16).

Regulations in America and Japan for diesel vehicles have promoted a variety of research aimed at reducing the NOx concentration in diesel exhaust. Whilst water injection has proved technically successful, the practical and marketing problems of separate water injection or pre-emulsification of water and fuel excludes any likely application of this approach on a commercial scale. Exhaust gas recirculation has proved the more practical, if limited, means of lowering NOx levels.

Odour

Passing reference has been made to diesel odour, which can arise from the fuel itself as well as the small amounts of unburnt hydrocarbons emitted in the exhaust. Heavier hydrocarbons will more readily break down under heat treatment than lighter ones; hence, hydrocarbons emitted from a diesel engine are likely to be different in nature from those in the fuel itself. There has been much specualation and research on the possible carcinogenic nature of such substances. Indeed, as with petrol exhaust, it is possible to identify the presence of polynuclear aromatic hydrocarbons usually ascribed carcinogenic properties. To date it has not been shown that the nature of polynuclear hydrocarbons from diesel engines could be any more harmful than those from petrol engines. Some data on this point were given by Kraeft (1) a few years back. Whilst his data are a little tentative and the methods of sampling and measuring not fully proven, little else is known to the author to dispute the observations displayed in Fig. 1, which shows abstracts of data from Kraeft's report. Only two engines are represented by this data and it would be incorrect to imply that the differences justify a general conclusion that there is significantly less emission of polynuclear aromatics from diesel than gasoline engines but such a conclusion is not without some precedent.

Measurement of low concentrations of such pollutants must be carried out by sensitive gas chromatographic analysis techniques which need careful control both with respect to measurement and sampling. Similar chromatograph techniques have been tried for

the measurement of odour from diesel engines. Here, there is the added complication that whatever chemical compound or concoction of components might be identified as having an odour has to be given some coding of nastiness as well as intensity. All individuals will not agree and even panels of people will not give consistent assessments on nastiness levels. Work by a number of investigators including research workers from Fiat, Ricardos, Daimler Benz and the Institut Francais du Petrole (IFP) (2) has applied and modified the original Arthur D Little chromatographic procedure which measures and relates the liquid chromatographic oxygenate and liquid chromatographic aromatic peaks in the exhaust analysis. They conclude that there are other contributors to odour sensations, ie aldehydes as sensory irritants and sulphur compounds, which do not influence the instrument odour measurements.

Some conclusions of odour measurement work are that odour levels from Direct Injection (DI) are generally higher than Indirect Injection (IDI) diesels but the reverse of this may apply to more recently developed DI engines. A decrease in the volume of the nozzle sac will reduce the odour but increase the mass of emitted soot(2). It might appear that any means which improve the efficiency of combustion will reduce the odour level of the exhaust.

Noise

Whilst noise is a problem associated with combustion aspects of the diesel engine, many of the noise complaints associated with diesel engines are more truly related to the size of the vehicle. It is unlikely that a 40 tonne truck carrying bulk cargoes would be any less objectionable with a petrol engine rather than

diesel. However, the diesel driven off-road dumper truck, tractor or crane working on a building site, with no engine noise shielding, can be a serious noise menace and certainly more objectionable than a petrol engine doing the same job. Because of the better economy and the fuel handling safety for sites where building and civil engineering is being pursued, there is little that can be said against the use of the diesel engine in these circumstances. There are, however, strong arguments for sound screens where they do not exist on the off-road vehicles and engines used on civil engineering sites.

With respect to heavy vehicles, it is appropriate for the Society to give voice to a policy suggesting maximum weights of vehicles for different categories of roads.

DESIGN AND PERFORMANCE COMPARED WITH THE PETROL ENGINE

Because there must be some attempt to suggest in which respects the diesel engine in its present or future form should or should not be used in preference to the petrol engine as a benefit to the environment, it is useful to consider relative design limitations. Effecting auto-ignition imposes the fuel limitation which is linked to the engine speed; ie, there must be some finite time allowed for ignition to take place after injection which should not be such as to allow too much fuel to be involved at once. With relatively slow speed, large engines, designed to develop substantial power, no undue problems are involved but the design of light-weight compact engines for the smaller mobile machines or vehicles has had to be approached by the following two methods.

1. The use of an indirect combustion chamber, whereby the fuel is directed into a small chamber connected to the main combustion space by a restricted passage. Fuel entering the small combustion chamber is ignited by the very turbulent premixing of fuel and air in the small, compact space. The ignition of the early part of the charge acts as an ignition torch for the remainder of the charge.

2. Supercharging. This is usually by a turbo-charger utilising energy in the exhaust to increase the mass of air compressed and, as a consequence, the amount of fuel which can be injected during each compression cycle. Essentially turbo-charging reduces the size of the engine necessary for a given power requirement.

Whilst indirect injection has a greater potential for reducing the emission of gaseous pollutants and smoke, it has adverse effects on specific fuel consumption due to high friction, pumping and heat losses. Until recently IDI engines were used exclusively in small commercial vehicles and diesel powered private cars which are gaining favour in most of Europe. Advances in direct injection design, according to manufacturers' claims, have now made them suitable for small high speed engines (4).

It is in compromises between fuel economy and level of emissions that the diesel engine has the greatest opportunity for gaining advantage over the petrol engine. Impetus was given by the advent of the EEC regulations on car fuel economy which was given the power of law in the UK by the UK Car Fuel Consumption Order (3). The following Table 1 compares similar petrol

and diesel European cars on fuel consumption and performance criteria in the "as manufactured" condition. If it is assumed that diesel engines are no better than petrol engines with respect to gaseous emission, the economy advantages of the diesel have to be weighed against relatively minor performance disadvantages and those unspecified disadvantages of greater smell, particulate emission and noise from the diesel engine. This inevitably leads on to the question of how much tolerance may be given to particulate emissions of the carbonaceous variety. There are several ways in which particulates are objectionable:

1. health;
2. soiling and damage to buildings;
3. visibility impairment -
   a) acute safety effects on other users,
   b) more general atmospheric environment effect;
4. general dirt level on clothing and in the indoor environment.

Only in respect of soiling and damage to buildings and possibly clothing and indoor cleaning is it possible to make any kind of cost analysis against the fuel saving potential of diesel engines. There are always insuperable difficulties in putting economic values to life and health. As we take so many risks to our life and health willingly, how do we judge those risks which are unacceptable?

From the Table 1 it is seen that in all cases the performance of the diesel vehicles, as measured by acceleration, is not as good as petrol engines. It is also noticeable that the economy advantage is most significant under urban driving conditions. This is because the power of a petrol engine is reduced by

throttling the total mass intake of air and fuel so that a lower cycle efficiency is achieved. In the diesel engine only the fuel intake is reduced to lower the power, whereby the cycle efficiency is more readily maintained. In the contrasts of fuel consumption at high constant speed, the better fuel consumption of the diesel is largely attributable to the higher energy content of a gallon of diesel fuel versus a gallon of petrol, on account of its higher density. If the comparison were to be made on miles per unit weight of fuel, there would be little difference between petrol and diesel engine fuel consumption under high load conditions.

Thus it can be postulated that the most significant energy saving advantage of a diesel engine to the small vehicle owner is in the urban situation, where the nuisance and perhaps hazard of diesel smoke is greatest. There is the positive advantage of lower CO and hydrocarbon emissions exhibited by most diesel engines which it does not seem possible to exploit to reduce smoke by very much.

From a theoretical standpoint it may be generalised that inefficiency in the operation of a petrol engine gives rise to the emission of volatile hydrocarbons and carbon monoxide; inefficiency in the operation of a diesel engine results in emissions of carbon and carbonaceous materials. Now volatile hydrocarbons and carbon monoxide are themselves noxious and undesirable but their emission from petroleum vehicles may be readily controlled by catalytic devices. Catalysts can be equally effective in burning up carbon and carbonaceous residues of inefficient combustion processes but the process is somewhat slow so that it is difficult to achieve a compact design of catalyst afterburner which can be effective for

a diesel engine operating throughout the range of light to full load. It may of course be remarked that, under urban conditions, diesel engine combustion should not be inefficient. Catalyst devices for the control of gaseous emissions and particulates from diesel engines have been designed by some catalyst manufacturers and applied to stationary and large mobile equipment with some success (7).

Workers at the Department of Industry's Warren Spring Laboratory have compared gaseous emissions from diesel and petrol vehicles in the UK in overall operation, based on emission factors for various driving modes (8). Unfortunately particulate emissions are not included. These data shown in Table 2 suggest that complete dieselisation of transport in the UK would make a near ten fold reduction in CO and hydrocarbon emissions whilst nearly doubling the NOx emissions. D.J. Ball in The Science of the Total Environment 33 (1984) suggested that diesel engined vehicles produced before 1984 emitted about 4 times the mass of particulate matter per unit weight of fuel as petrol engined vehicles (9). In the same paper, Dr. Ball estimates the smoke emission from diesel engined vehicles in London: on the basis of fuel consumption of some 520,000 tonnes per year, is 3000 tonnes. This would suggest that completely dieselised transport in the UK would emit approximately 150,000 tonnes of particulate against the all-petrol transport level of 43,000 tonnes, in which estimate a 15% higher petrol than diesel fuel consumption has been assumed. A summary comparison of estimates of various emissions from an assumed population of all diesel and all petrol vehicles in the UK is made in Table 3 but must obviously be regarded as only a very rough guide to hypothetical circumstances. The estimate is justified only by the assistance it

might give in formulating a policy approach to diesel vehicles on environmental grounds.

The figure of 150,000 tonnes of particulate is an approximate and probably low estimate of the emissions of an all-diesel road vehicle population in the UK. Whilst this contrasts with the 2.3 million tonnes of particulate emitted annually from all sources during the early 50s and might suggest no great consequence arising from complete road vehicle dieselisation, this figure of 150,000 tonnes does equate approximately to the level of present day domestic emissions and would also correspond to half the smoke emitted from the railways during the days of the steam engine (10).

However tolerable such emission levels might be considered in the light of past levels to which we have subjected ourselves, to allow a further increase in the concentration of particulate matter in the atmosphere would be a retrograde step. It is therefore important that either means must be found to reduce particulate emissions from diesels to the level of equivalent petrol engines, or further penetration of the diesel engine into the automotive market should be limited.

DESIGN DEVELOPMENTS IN ENGINES AND FUELS

In recent years there have been many developments in engines, fuels and also vehicles, that have a bearing on pollutant emissions either directly or indirectly by affecting fuel consumption. Computer technology has been significant in these developments both with respect to more precise engine control but also in thermodynamic modelling for engine combustion chamber design. In contrast with the "suck it and see" research

which characterised previous decades of engine combustion technology, the present decade should provide means for better control of undesirable emissions. However, it is important that the incentive to improve emissions is there. International competition in all applications of the diesel engine gives strong reason for the application of advanced technology to improve performance and reduce fuel consumption but such improvements are not necessarily associated with reduced emissions. Essentially it is only legislation that can give sufficient stimulus in this respect. Earlier references have been made to basic features of the diesel engine which have caused problems in the design of high speed engines suitable for the smaller vehicles. Turbo-charging, which is being used to assist in this problem, has long been used in the large vehicle engine to improve the vehicle economy and by virtue of smaller engine size for a given duty does give some reduction in noise. More recent developments which gain additional advantage from computer technology are variable geometry turbo-charger systems, which go some way to match thermodynamic and flow characteristics of the engine and turbo-charger. It is to be hoped that such systems, which will have reliability problems to solve, will give improvements in particulate and gaseous emissions on the road as well as in prototype tests.

Recent developments in DI (direct injection) engine design have created a breakthrough for the adaptation of diesels to the small lightweight vehicle where high speed engines are necessary to provide realistic competition to the petrol engine car. Ford Motor Company were the first to introduce DI into the small vehicle engine but have not pushed the idea vigorously for adaptation to passenger cars and

would seem more enamoured of the lean burn petrol engine, certainly as the predominating engine concept for the UK (11). More recently Austin Rover, in conjunction with Perkins, have announced that they have significant leadership in the design of a DI high speed small engine. It is claimed that the engine has 40% better fuel consumption than an equivalent petrol engine. The combustion chamber is a bowl shaped recess in the top of the piston in which all burning takes place, thus reducing the heat losses which normally take place through the engine cylinder walls. By the careful design of the combustion space and fuel injectors, good mixing of fuel and air over a wide range of engine speeds is claimed. The two litre capacity engine operating at speeds up to 4,500 rpm is said to develop 62 bhp naturally aspirated and 80 bhp in turbo-charged form (12). The claimed improvement in fuel consumption, which might be estimated to give a consumption figure of 60 mpg, should also imply very low carbon monoxide and hydrocarbon emissions. Replacement of petrol-engined vehicles by vehicles with this type of engine could effect substantial reduction in these two pollutants. Recent concern about the contribution of hydrocarbon emissions from road vehicles to acid rain and its reputed effect on trees should give some reason for encouraging such a trend. However, there is little doubt that any such change of vehicles on the road would not reduce levels of particulate emission; in fact, they would be increased and indeed sulphur dioxide emission would also be increased.

Within the next three years new petrol - engined vehicles should be legally obliged to be manufactured to operate on unleaded petrol (13). The octane number level of the premium unleaded petrol which the oil industry will

also be obliged to make available will be 95, which is 2 numbers lower than present quality. A consequence of this will be less improvement in the fuel consumption of petrol driven cars, if not some deterioration during the intervening years in which suitable cars will be developed. This could give an opportunity to the diesel engine to gain further improvements in relative fuel consumption.

To the chagrin of the diesel engine designer, difficulties relating to the quality of diesel fuel have occurred as a result of the various factors which have disturbed the oil product demand pattern of the earlier years. The reduced number of refineries in Europe have had to produce more distillate but less fuel oil by utilising conversion plant capable of converting fuel oil fractions into petrol and diesel fuel. A detailed study has been made by Unzelman of the effect of these changes on diesel fuel and the means of overcoming the loss of cetane quality that comes about when the aromatic hydrocarbons produced by the conversion processes replace the more paraffinic and naphthenic hydrocarbons of straight distillate (14). These aromatic hydrocarbons are comparatively rich in carbon and poor in cetane number; both properties can be improved by hydrogen treating. Cheaper methods of increasing cetane numbers (ie promoting auto-ignition) are the additives called cetane improvers, usually organic nitrates. There is at the present time uncertainty as to whether the measured or calculated cetane numbers of the non-straight run distillates, ie the products of conversion refineries, give a proper comparison of fuel performance in modern diesel designs. Hence measuring procedures are under serious review. Until a revised procedure has been developed, engine manufacturers will be uncertain of the

engine performance and smoke producing tendency of their engines over the range of fuel product conforming to the present standard specification. There have been proposals for a premium grade of diesel fuel for small high speed engines and indeed, if diesel cars are to proliferate, any assistance that fuel quality can provide to reduce smoke should be encouraged. Any such proliferation of diesel cars could accentuate adverse reaction to the smell of diesel fuel itself, as distinct from exhaust odours. Leakages on vehicle fuel systems and spillages during vehicle tank filling are most likely to give rise to these difficulties.

CONCLUSIONS

1. From the foregoing review of diesel engines and the polluting emissions they produce, there is little doubt that their most significant disabilities are: noise; smell and particulate emissions (smoke).

2. The off-road noise of civil engineering equipment on building sites is a problem which could be dealt with by improved sound screening of engine compartments.

3. The noise and vibration caused by the heavier road vehicles is a problem of traffic management. Many roads used by heavy vehicles are unsuited to the vehicles and it is suggested that legislation to limit the use of larger vehicles on unsuitable roads might be beneficial.

4. Smell is to a large extent related to the degree of gaseous emissions, particularly hydrocarbon and hydrocarbon derivatives. The technology currently being applied to combustion systems and turbo- or

super-charging should provide means of reducing exhaust odours to acceptable levels. The smell of unburned fuel is very objectionable to some people and perhaps more tolerable to others than the smell of petrol. It is expected that any greater proliferation of diesel cars will give rise to adverse reaction on this account.

5. Improvements in diesel engine design are going a considerable way towards bringing the performance of small diesel engines up to that of equivalent size petrol engines, with reduced fuel consumption. These better fuel consumption levels on a per gallon (volume) basis give an exaggerated impression of energy saving since there is approximately 13% more energy in a gallon of diesel fuel than in a gallon of petrol. However, such energy saving as there is would represent a reduction in gaseous pollutant levels where petrol engines are replaced by diesels. Contrary to this improvement in gaseous pollutants, any replacement of petrol by diesel cars will increase particulate pollution levels and levels of sulphur dioxide pollution originating from road transport.

6. In view of the improvements in gaseous emissions and impending reduction of lead emissions from petrol driven vehicles and cars, as well as the expectation of increased particulate emission that a further increase in diesel cars could bring about, it would seem more appropriate for the National Society for Clean Air to oppose rather than support dieselisation of small vehicles used for private transport.

REFERENCES

1. D Kraeft, "Measurement techniques and problems of unregulated emissions". Co-ordinating European Council International Symposium on the performance evaluation of automotive fuels and lubricants. June 1981.

2. P.H. Degobert, "Evaluation of diesel odorous emissions". Co-ordinating European Council International Symposium on the performance evaluation of automotive fuels and lubricants. June 1981.

3. Passenger car fuel consumption order 1983. HMSO.

4. Technological advances in vehicle design, Ford Energy Report. Proceedings of the International Association of Vehicle Design. Special Publication SP1 1982.

5. New Car Fuel Consumption, October 1985, Department of Transport.

6. Autocar Road Tests.

7. R A Searles, "Catalytic control of automobile exhaust emissions and industrial odours and emissions". Johnson Matthey Chemicals. August 1983.

8. F S M Rogers, "A revised calculation of gaseous emissions from UK motor vehicles". Warren Spring Laboratory, Department of Industry. Report LR 508(AP)M, 1985.

9. D J Ball, "Environmental implications of increasing particulate emissions resulting from diesel engine penetration of the European automotive market". The Science

of the Total Environment 33 (1984). Elsevics Science Publishers BV Amsterdam.

10. M W Holdgate, "A perspective of environmental pollution". Cambridge University Press, 1979.

11. R W Mellor, "Passenger car technology - thirty years of advance". Proceedings of the Institute of Mechanical Engineers, Volume 200, No 77, April 1986.

12. K Gooding, Financial Times, July 1986.

13. BS 7070: 1985 Unleaded petrol (gasoline) for automotive vehicles.

14. G H Unzelman, "Diesel fuel demand. A challenge to quality". Paper presented to the Energy Economics Group of the Institute of Petroleum, October 10, 1983. Published by Ethyl Corporation.

15. Proposal for Council Directive amending Directive 70/220/EEC. EEC O.J. 1986.

16. Proposal for a Council Directive on the approximation of the laws of the Member States relating to the measures to be taken against the emission of gaseous pollutants from diesel engines for use in vehicles. EEC O.J. 1986.

TABLE 1

Vehicle Description	Fuel Consumption (miles/gal)					Autocar Performance Tests [6]		
	MOT Specification [5]			Autocar Test (Overall)	Autocar Estimated (Typical)	Acceleration (sec)		Maximum Speed (mph)
	Urban	56 mph	75 mph			0-60 mph	50-70 mph	
Rover SD1 2300/S	20.9	43.6	33.7	22.8	24.0	11.9	8.4	111
Rover SD1 2400SD Turbo Diesel	30.2	46.7	32.7	29.6	32.6	14.3	10.0	104
Mercedes 190E (Petrol)	27.6	48.9	36.2	27.9	30.7	9.7	7.4	121
Mercedes 190D (Diesel)	37.6	56.4	42.7	30.8	33.9	15.9	11.0	98
VW Passat 1.8 Saloon	33.2	51.4	38.7	30.7	33.8	11.9	7.9	103
VW Passat Turbo Diesel	42.2	62.8	44.1	40.7	44.7	13.6	10.0	101
Volvo 760 GLE	17.0	34.9	26.6	20.3	22.3	10.8	6.4	114
Volvo 760 GLE Turbo Diesel	31.0	47.1	33.2					

TABLE 2

GASEOUS EMISSIONS FROM PETROL AND DIESEL

ENGINE VEHICLES IN THE UK

(F S M Rogers, DoI, Warren Spring Report LR 508(AP)M)

YEAR	Total Automotive Fuel Consumption ('000 Kt)			CO Exhaust Emission (Kt)			Hydrocarbon Emission Exhaust + Evaporative (Kt)			Oxides of Nitrogen Exhaust Emission (Kt)		
	PETROL	DIESEL	PETROL / DIESEL	PETROL	DIESEL	PETROL / DIESEL	PETROL	DIESEL	PETROL / DIESEL	PETROL	DIESEL	PETROL / DIESEL
1981	18.72	5.5	3.74	7513	228	32.9	950	37	25.6	309	167	1.85
1982	19.25	5.7	3.36	7726	235	32.9	977	38	25.7	318	173	1.84
1983	19.57	6.2	3.16	7854	254	33.6	993	41	24.2	323	185	1.74

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AIR POLLUTION AND THE DIESEL ENGINE:
Prospects for smoke emission control

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SUMMARY: A noticeable feature of British and European towns is the smoky atmosphere generated by trucks and buses. In the past there has been a tendency to regard these emissions as either an amenity problem, or affecting only road users, with the result that they have not been seen as a priority for control. However, it is now becoming recognised that these 'soot' emissions, which are concentrated in the centres of population and released in the breathing zone, have implications for public health, the soiling of buildings, and atmospheric visibility. The problem is being tackled in America over the next few years by the introduction of new standards which will have the effect of substantially reducing these emissions. These standards will rely very much on technological advances which have been achieved in Europe. Recent proposals to limit diesel smoke emissions in Europe, where diesels are already well entrenched, are less demanding than their American counterparts, and as things stand it seems unlikely that the new technology will be required on this side of the Atlantic.

1. Introduction

Smoky transport and commercial vehicles are a familiar sight in British towns and on the roads, and have for many years been a focus of public concern. Yet, compared with the petrol engine, the diesel has received comparatively little attention. Campaigns to curb these emissions have not achieved the impetus of those concerned with lead or 'acid rain', and for many years there has been a tendency to categorize the problem as simply a matter of amenity, or affecting motorists only, with the implication that it was of lesser importance.

However, it is now beginning to be recognised that diesel smoke emissions do have important implications for the health and welfare of urban populations and that there is a case for substantial revision of legislation to bring about improvements as a matter of priority. Thus, in the United States, concern over the projected growth in numbers of diesel vehicles has led to the introduction of stringent standards to limit smoke (particulate) emissions from both light and heavy-duty diesels. Recently, there are also signs of action in Europe, where diesels already dominate the commercial market, and are currently making big in-roads into the passenger vehicle scene. In June this year, for example, the European Commission issued a proposal for restricting particulate emissions from diesel passenger cars.

It is the purpose of this paper to identify the environmental issues which underlie this change in attitudes, and to report on new ideas about the control of diesel smoke emissions.

2. An Issue of Long-standing Public Concern

First, it is worth noting how long the problem has existed. As early as 1954, while contending with other extremely serious environmental problems, Sir Hugh Beaver found time to observe that,

> 'Smoke from diesel engines can be a serious nuisance. It is discharged at a low level and may even at times endanger traffic by reducing the field of vision. The dirt it deposits on windows, lamp posts and other objects in the street is objectionable and difficult to remove.'(1)

a point of view which has been echoed countless

times since. In the mid-1960s Dr L.E. Reed, unmtil recently Chief Alkali Inspector, identified diesel smoke emissions as causing 'the loudest outcry' from the British public (2), and the results of public opinion surveys (3) are consistent with this view being maintained through to the present era.

Throughout this period concern has likewise been expressed by many eminent bodies including the National Society for Clean Air (4) and the British Safety Council (5) who have campaigned for revisions in the legislation; and as recently as 1984, the Royal Commission on Environmental Pollution reported that,

> '.... we consider that smoke emissions from diesel vehicles in the United Kingdom are in many circumstances at an unacceptable level. We believe that there is scope for improving both vehicle construction standards and enforcement in use.'(6)

3. The Basis of Current Standards

It should be said that the problem of diesel smoke emissions has not passed unrecognised by industry and government. As long ago as 1963 the British Motor Industry Research Association (MIRA), in collaboration with the Ministry of Transport (MoT) and Warren Spring Laboratory (WSL), attempted to get to grips with the problem. A series of tests was carried out in which a panel of observers was asked to rate smoke emissions from a number of diesel-engined road vehicles as visually acceptable or otherwise (7). The following information, given to each observer, describes the method of the test;

> 'You are well aware that smoke from diesel-engined vehicles is a problem on the

roads today. We are trying to obtain an idea of the density of smoke which the public is prepared to accept and it is your opinion, as members of the public, that we want. We propose to seat you by the roadside and run a number of vehicles past you emitting smoke of various densities. Firstly, we ask you to decide if the level of smoke is acceptable or unacceptable to you personally. You are then asked to decide into which sub-category (clear, light, medium or dark) the smoke falls. Please do not allow the smell of the exhaust to influence your decisions on the visual aspect of the smoke. You are asked not to discuss your decisions with fellow members of the panel.'

The answer sheets completed by the observers during the tests were subjected to statistical analysis, from which graphs of the number of objectors versus smoke emission levels could be drawn for each of the vehicles used. From this it was possible to deduce the smoke emission level to which a given percentage of the panel objected.

Subsequently a British Standard, BS AU 141a, was formulated on the basis of the level of smoke emitted which was found to be acceptable to 50% of the observers (8). Figure 1 shows this 'limiting exhaust gas opacity curve', which sets the standard for new engines, as a function of exhaust gas glow rate. Because, in practice, the degree of correlation between light obscuration and soot concentration has been found to be variable, exhaust gas opacity is defined and measured directly by light obscuration smokemeters in the British Standard. The EC limit values (Directive 72/306/EEC), also shown in Figure 1, and which were evidently based on the British Standard,

are transposed slightly due to the specification of marginally different test conditions by the European Community.

4. The Significance of Diesel Particulate Emissions

The fundamental premises upon which the British Standard, and consequently the European Directive, is based, is that what the public objects to is the visible manifestation of diesel smoke, and that the problem of diesel smoke emissions will be solved if this can be rendered invisible to the naked eye at source. This is quite clear from the wording in the British Standard itself;

> "Exhaust smoke is objected to as a result of its light obscuration characteristics (opacity)'.(9)

Nonetheless, the basis for this belief is obscure. Indeed, a review of numerous opinion surveys into the public perception of the environmental effects of traffic which were carried out during the 1970s, indicates that the public are concerned with dirt and soiling associated with road traffic, and perceived health effects (10). Scientific evidence, which has important implications for the form of future legislation, is gathering in support of these views.

AIR QUALITY

The significance of diesel exhaust emissions to atmospheric particulate levels in urban areas in Europe was first brought to light in a study carried out in 1975 in central London. Daily measurements of lead and smoke, at roof top level, were found to be correlated to a remarkable degree (11), suggesting that motor

vehicles and not domestic sources (as had formerly been the case for many hundreds of years) were the dominant source of dark smoke in London. At the time this finding was considered controversial, but it was soon supported by similar measurements in Paris (12), and by simple calculations based on fuel use and smoke emission factors which are reproduced in Table 1.

A recent compilation of black smoke emissions in the UK by Dr Martin Williams (WSL), shown in Table 2, confirms the importance of diesel emissions on a national basis.

Although other cities have not necessarily the same degree of domestic smoke control as London, reports suggest that the relative importance of diesel smoke emissions is widespread. In Dublin, for example, motor vehicles have been estimated to contribute 15% of particulate levels at non-streetside locations, most of which is ascribable to diesels (14). The results of calculations in the Netherlands, shown in Table 3, indicate clearly the dominance of diesel emissions on airborne smoke levels in that country, particularly in cities (15). Air quality measurements in London (16) and Leeds (17), where smoke levels in the vicinity of traffic can be 30 to 70 ug/m higher than the urban background, confirm the importance of vehicular emissions in determining the smokiness of city environments in the current era.

HEALTH

Even in congested urban areas where diesel vehicles can, as has been seen, contribute significantly to smoke levels, this should not by itself be a cause of symptoms of respiratory disease. However, combined with particulate

emissions from other sources, they could in certain areas exceed air quality standards and cause a concomittant rise in respiratory disorders. In addition, consideration of the basic aspects of the physical and chemical identity of diesel particulates indicates the need for a cautionary approach.

Although diesel particulate emissions consist substantially of carbon, their very fine particle size (mass median diameter 0.1 to 0.2 um) means that they will penetrate deeply into the lung, with about 50 per cent depositing in the pulmonary region, where they are likely to remain for comparatively long periods prior to clearance from the respiratory system. There they may act by slowing the pulmonary clearance mechanism, or by acting as carriers for toxic agents.

Attempts to pin down the health implications of diesel particulate by epidemiological studies, and by extrapolation from animal experiments, have, as is often the case, been fraught with difficulties. For example, the Health Effects Panel of the US National Research Council, in a recent review, was unable to reach other than tentative conclusions as much of the research was found by them to be incomplete (18). Nonetheless, it is well known that hydrocarbon emissions from diesel engines are readily adsorbed onto the fine carbon particles (19), and that these include such organics as polyaromatic hydrocarbons and nitroarenes which have a significant activity in short-term mutagenicity assays that might be indicative of a potential for inducing cancer 20 to 30 years later. Tests of the polyaromatic hydrocarbon content of a range of engine/fuel systems have shown the highest emissions to be associated with diesel-fueled vehicles (20).

It would seem logical therefore that emphasis should be placed on restricting smoke and trace organic emissions from diesel vehicles in any programme concerned with curtailing vehicle emissions as a means of protecting public health.

SOILING

Although many buildings in our towns and cities have now been cleaned, these are still subject to continuing soiling caused by the deposition of soot. Of all particles in the atmosphere, those most responsible are the fine carbon particles because of their small size and hence high covering power, their high optical absorptivity (blackness), and their adhesive qualities.

As Table 1 showed, motor vehicles are now the dominant source of smoke emissions in London. To assess their significance as contributors to soiling, relative soiling factors for different kinds of smoke have been introduced in Table 4 (column 2). As a first approximation, the product of columns 1 and 2 gives an idea of the soiling propensity of each source type, from which the relative soiling index of each source can be readily calculated (column 3). Clearly, diesel vehicles are of highest significance, a finding which has since been reaffirmed by studies in both Holland and W. Germany, where diesels have been found to account for 75 to 90% of soot emissions (21).

Precisely what this means in terms of annual cleaning costs is difficult to assess, but the sums involved could be very large. The cost of cleaning stonework, for example, was in the range £2 to £4 per square metre a few years ago, and there are probably about 30 million sq metres of commercial facades in the central

business district of London alone (22). According to Dutch calculations, buildings in urban areas are likely to require major cleaning activities as a result of atmospheric soiling about every 8 years (15). Of course, all sectors of the community are subjected to soiling including the residential sector. The total cost of soiling in the Netherlands has been estimated at about £250 million per annum although the precise contribution of diesels to this is more difficult to assess. However, calculations which relate specifically to diesels have been made of the cost of soiling of Californian domestic households should there be an increase of 20% in the number of diesel cars on the road. The costs fall in the range of S220 million to S2700 million annually (23): the range is extraordinarily wide because of the complexity of estimating cost.

VISIBILITY

The impact of diesel particulate emissions on atmospheric visibility is also a subject of concern in some countries, even to the extent of taking precedence over health and soiling effects, probably because it is more easily quantified. Again, it is the fine particle size of the soot emissions, together with their absorptive properties, which are at the root of the problem. For example, it has been calculated that a 20 per cent dieselisation of light-duty vehicles in California, in the absence of new controls, would reduce visibility by between 10 and 25 per cent (24). What this means in practice is that for a city such as San Francisco, the present baseline visibility of from 15 to 20 miles, would fall to 10 to 15 miles. The relative effect in Europe of diesel particulates is lower, estimated at about 4% (15), because of the higher quantities of other light scattering

species (sulphates and nitrates) in the atmosphere, but is nonetheless significant. Smoke emissions can also give rise to localised problems, for example in road tunnels, where their effect on visibility is one of the determining factors in ventilation design.

5. Past and Future Standards

After the British Standard (BS AU 141a) was adopted in 1971 concern over smoke emissions continued to be expressed by the public and environmental organisations alike. This is perhaps not surprising since, apart from the fact that it does not tackle the question of health and soiling, the Standard, by its own criterion, requires no more than that new diesel engines should be visually acceptable to 50 per cent of observers. Since engines deteriorate on the road, it can only be concluded that a substantial majority of the public would find smoke emissions unacceptable even when judged by the Standard's own criterion. This problem may well have been realised early on by the then Undersecretary for Pollution, Mr. Eldon Griffiths, who acknowledged that the Specification might have to be amended from time to time in the light of experience (25). However, despite frequent representations from the NSCA that, for example, a more severe limit of 75 per cent acceptance by the panel of observers should have been adopted (25, 26), no new proposals were forthcoming in the years which followed. Recently, however, in response to the concern expressed by the Royal Commission on Environmental Pollution (6), it has been agreed that there is considerably scope for improving the construction standard governing smoke emissions from diesel-engined vehicles (27). This has been paralleled by developments on both the light-duty and heavy-duty diesel

vehicle front in Europe as described below.

LIGHT-DUTY VEHICLES

In June this year the European Commission submitted a proposal for a Council Directive (28) to reduce smoke emissions from diesel cars specifically, the proposal is:

	Type approval	Conformity of production
cars above 2.0 litre*	1.4g/test	1.8g/test
cars below 2.0 litre£	1.1g/test	1.4g/test

* from 1 October 1988; £ from 1 October 1991

HEAVY-DUTY VEHICLES

it is understood that in 1985 a European initiative was taken by Britain in proposing to the Economic Commission for Europe (ECE), that there be an approximate 30% improvement in the smoke emission limits currently specified in BS AU 141a and the equivalent ECE regulation.

6. Discussion

LIGHT-DUTY VEHICLES

The new proposal by the Commission is interesting on several counts. Firstly, the need to protect public health is acknowledged in the proposal. Secondly, a mass-based emission standard is proposed as the means of achieving this. Logically, this is an important step because, unlike the current visual amenity criterion, it is more relevant in terms of air quality considerations and hence health and soiling effects. There are also a number of other benefits, such as the ability to progressively tighten emission

standards as technology and practicability allow (29).

Thirdly, it is of interest to compare the numerical values of the proposed standard with those already on the statute book in the USA, namely 0.6 grams per mile currently, falling to 0.2g per mile in 1987 (30). Since these figures relate to US test procedures, they must be converted to equivalent values on the ECE test cycle. This can be achieved, approximately, by multiplying by three (31). Thus, the US 1987 standard would be equivalent to 0.6g/test on the ECE cycle, i.e., a factor of about two lower than the Commission's proposal for cars below 2 litres. Also, it can be seen that the current US standard, equivalent to 1.8g/test on the ECE cycle, is little different from future European requirements (31). Since the majority of diesel cars in the US are of European origin, it would seem that the Commission's poroposal, if enacted, would not require any further innovation by manufacturers.

HEAVY-DUTY VEHICLES

No proposal has as yet been made by the Commkission on heavy-duty vehicles although these are currently responsible for the majority of diesel smoke emissions in Europe. The UK initiative is interesting in that, while it now recognises public concern over health and the environment, it seeks to retain the visual amenity criterion as the basis for control. The proposal that the numerical limits specified in BS AU 141a be reduced by 30% would, in fact, bring the Standard close to the 75% acceptability criterion requested by the NSCA some years ago.

The environmental impact of such a change is

difficult to ascertain. In terms of visual amenity, the benefits might be substantial, while in terms of the total mass of particulates emitted, to which health, soiling and atmospheric visibility are related, the reduction would likely amount to something less than 30%.

As a comparison, the particulate emission standards for heavy duty diesel vehicles issued by the US Environmental Protection Agency are listed in Table 5. These standards are required by US law to reflect the greatest degree of emission reduction achievable through the use of technology that EPA determines will be available in the year in which the standards are introduced. The standards must also incorporate consideration of cost, noise, fuel economy and safety.

Although comparison with the UK or European situation is difficult because of unavailability of data or differences in test procedures, it would seem that current emissions from heavy duty diesel vehicles on both side of the Atlantic are in the range 2 to 6g/mile (13, 14, 32). Thus although Table 5 is couched in unfamiliar units, the starting point would appear to be the same. Hence, what is important is the scale of reduction required, namely a factor of seven by 1994 for trucks, and by 1991 for buses.

Although these reductions are impressive, it is interesting to note that manufacturers generally did not dispute the claim that a 0.25 g/BHP-h standard could be met if certain control devices, known as trap oxiders, were available, although some concern was expressed over the 0.1g/BHP-h standard. However, even in the latter case, to be brought in as early as 1991 for buses in view of their particular

relevance to the urban environment and their greater amenability to control, some manufacturers still voiced support for the general feasibility of the standard (30).

7. CONTROL TECHNIQUES

Although not the purpose of this paper, a brief note on control techniques is appropriate. So far as cars are concerned, both the American and proposed Eujropean standards can be met by engineering improvements alone. To meet the US standards for trucks and buses, electronic fuel management systems will also be necessary, as will add-on devices known as trap oxidiers or catalytic trap oxidisers. Substantial progress has been made in all of these areas in recent years and it is the expectation of the US EPA that manufacturers will be able to comply with the new standards, and possibly even more stringent ones in the years to follow. It is likely that much of the new technology required to meet this challenge will originate from Europe where the majority of experience in design of advanced diesel engines resides. As a footnote, catalytic trap oxidisers are also very effective in removing diesel odours (33, 34).

8. CONCLUSIONS

- Diesel vehicles, especially transport and commercial vehicles, are a major factor in determining the smokiness of air in European towns. Diesel cars, which are rapidly increasing in popularity, are also a factor to be reckoned with.

- Although current legislation considers diesel smoke emissions solely in terms of a visual amenity problem, scientific evidence indicates the impacts are public health,

soiling of buildings, and atmospheric visibility.

- The European Commission has proposed a Directive setting mass emission limits for smoke emissions from diesel cars. The proposal recognises the need to protect public health, but has been reported as not improving on existing emission standards. American standards for diesel cars are twice as stringent.

- The European Commission has not proposed any new regulations for heavy duty vehicles, although a UK initiative has suggested that the current visual amenity criterion should be made 30% more stringent. In the US, regulations for trucks are seeking a seven-fold improvement over current smoke emission levels by 1994 (1991 in the case of buses). The latter will be achieved largely by the use of technology developed in Europe.

- As things stand, it appears that a mixed system of units could prevail for diesel vehicles in Europe, with a mass emission standard for cars, and a visual amenity criterion for trucks and buses.

9. ACKNOWLEDGEMENTS

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REFERENCES

1. Sir Hugh Beaver (1954), Report of the Committee on Air Pollution, Cmd. 9322, HMSO.

2. L.E. Reed (1966), 'Vehicle exhausts in relation to public health', paper presented to the Royal Society of Health, London.

3. Department of the Environment (1978) and 1979), Digest of Environmental Pollution Statistics, Volumes 1 and 2.

4. National Society for Clean Air (1978) 'Road vehicles - are we doing enough?, Clean Air (Winter Issue), p. 4; and (1981) submission to the Minister of Transport, as reported in Clean Air, Volume II, No. 1, pp 17-18.

5. British Safety Council (1977), 'Smoke pollution from the diesel engine', report by B. Walsh.

6. Royal Commission on Environmental Pollution (1984), "Tackling pollution _ experience and prospects', tenth report, Cmnd. 9149, p. 135, HMSO.

7. A.E. Dodd and L.E. Reed (1964), 'The relationship between subjective assessment and objective measurement of exhaust smoke from diesel-engined road vehicles', Motor Industry Research Association, Report No. 1964/12.

8. M.V. Ellis (1979), 'Legislative control of motor vehicle emissions'. Paper presented at workshop on pollution from road vehicles, University of Warwick.

9. British Standards Institution (1971), 'The performance of diesel engines for road vehicles', BS AU 141a. Available from BSI, 2 Park Street, London W1A 2BS.

10. D.J. Ball and R. Caswell (1983), 'Smoke from diesel-engined road vehicles: an

investigation into the basis of British and European emission standards', Atmospheric Environment, 17, pp 169-181.

11. D.J. Ball and R. Hume (1977), 'The relative importance of vehicular and domestic emissions of dark smoke in Greater London in the mid-1970's', Atmospheric Envireonment, 11, pp1065-1073.

12. A. Roussel (1983), 'Impact medical des pollutions d'origine automobile', Report to the French Ministries of Environmental and Health, Paris.

13. M.L. Williams (1986), 'The impact of motor vehicles on air pollutant emissions and air quality in the UK - an overview', paper presented at Second International Symposium on Highway Pollution, Middlesex Polytechnic.

14. Dublin Corporation (1984/85), Environmental Pollution Report.

15. K.D. van den Hout and R.C. Rijkeboer (1986), 'Diesel exhaust and air pollution', Report No. R86/038, TNO.

16. Greater London Council (1984), 'Air pollution statistics for London - sulphur dioxide and smoke, April 1981 - March 1983', Statistical Series No. 36.

17. A.G. Clarke and I. Papapanayotou (19896), 'Optical and chemical properties of roadside aerosols', Paper presented at the Second International Symposium on Highway Pollution, Middlesex Polytechnic.

18. National Research Council (1981), 'Health effects of exposure to diesel exhaust',

MNational Academy Press.

19. D.S. Barth and S.M. Blacker (1978), 'The EPA programme to assess the public health significance of diesel emissions', J. Air Pollut. Control Assoc., 28, No. 8, pp 769-771.

20. K-E. Egeback et al (1983), 'Chemical and biological characterisation of exhaust emissions from vehicles fueled with gasoline, alcohol, LPG and diesel', Swedish Environmental Protection Board, Report No. 1635.

21. R.W. Lanting (1985), 'Black smoke and soiling', paper present at Second US-Dutch International Symposium on Aerosols, Williamsburg, Virginia.

22. D.J. Ball (1984), 'Environmental implications of increasing particulate emissions resulting from diesel engine penetration of the European automotive market', The Science of the Total Environment, 33,k pp 15-30.

23. R.F. Sawyer and W.J. Pitz (1983), 'Assessment of the impact of light duty diesel vehicles on soiling in California', Report to California Air Resources Board.

24. J. Trijonis (1982), 'Impact of light duty diesels on visibility in California', Paper presented to California Air Resources Board.

25. National Society for Clean Air (1972), 'Smoke demonstration from diesel vehicles', Clean Air, Spring, pp9-10.

26. National Society for Clean Air (1980),

'Pollution from road vehicles', p. 54.

27. Department of the Environment (1984), Pollution Paper No. 22, p. 21.

28. European Commission (1986), 'Proposal for a Council Directive 70/220/EEC on the approximation of the laws of Member States relating to measures to be taken against air pollution by gases from engines of motor vehicles (restriction of particulate emissions from diesel engines), COM(86) 261 final, Official Journal of the European Communities, No. C17413, pp 3-17.

29. D.J. Ball (1982), 'Smoke from diesel vehicles - is it time for a mass-based emission standard?', Clean Air, volume 12, number 2.

30. Rapporteur for the United States (1985), 'Control of oxides of nitrogen and diesel particulate emissions from heavy-duty vehicles', paper submitted to ECE Inland Transport Committee.

31. M.P. Walsh (1986), 'The Commission proposal for control of diesel particulate', report to the European Environment Bureau.

32. M.P. Walsh (1986), 'The benefits and costs of diesel particulate control IV - the in-use urban bus', SAE International Congress, Detroit.

33. A.J. Hickman and C. Jaffrey (1986), 'Performance and durability of a catalyst trap oxidiser installed on a city bus for 65,000 miles of revenue service', SAE International Congress. Detroit.

34. J.H. McCormick, B.E. Enga and J. Cunningham

(1986), 'Revenue service evaluation of CTO performance on an RTS2 bus in centre city Philadelphia', SAE International Congress, Detroit.

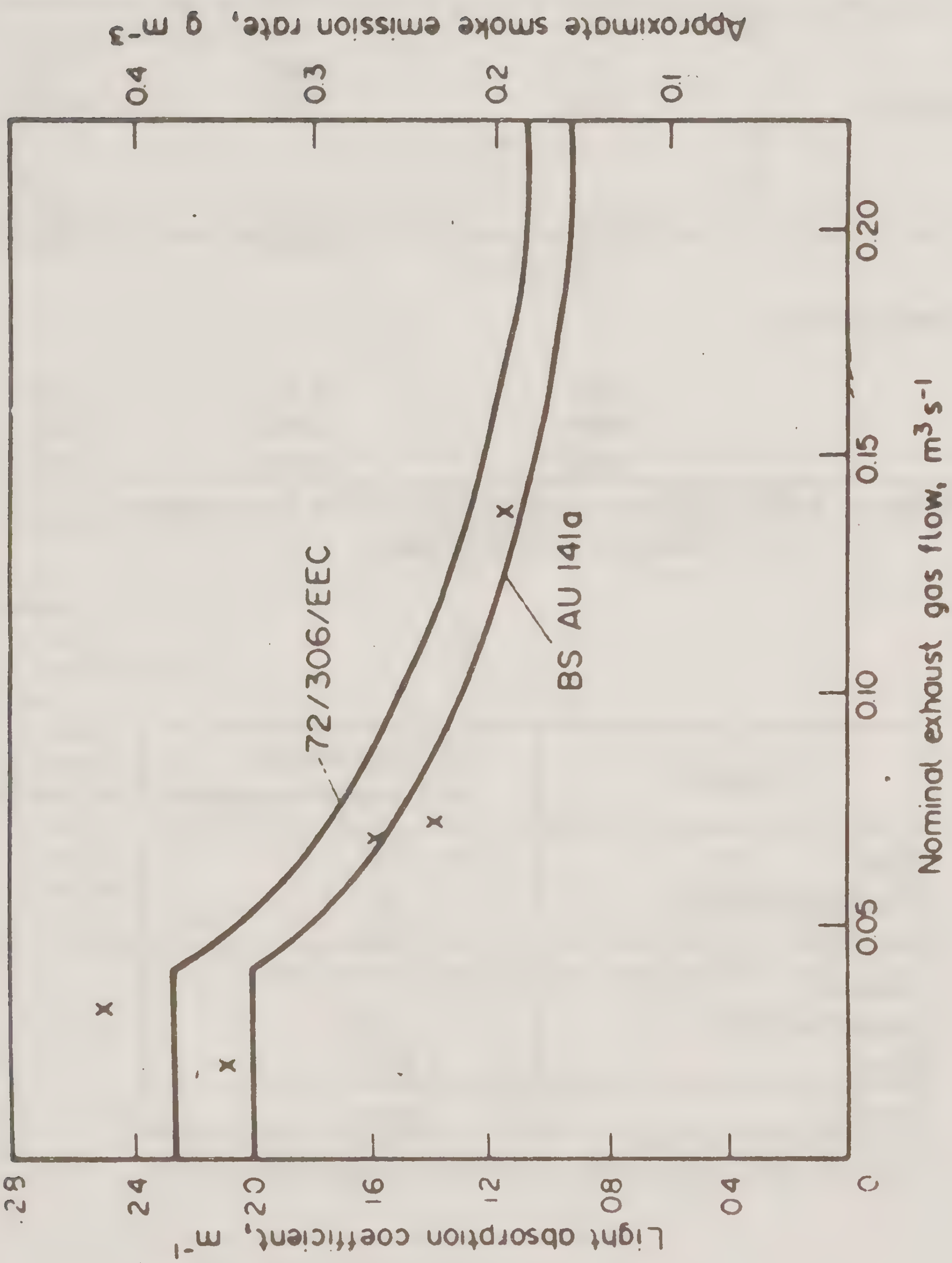

Figure 1. The 'fifty percent acceptability criterion' has been the basis of diesel smoke emission standards in Europe since 1972

Source and fuel type	Annual fuel consumption (10^3 tonnes)	Smoke emission factor (% by weight)	Smoke emission (10^3 tonnes)
Domestic			
- coal	50	3.50	1.8
- smokeless fuel	350	0.56	2.0
Vehicles			
- petrol	2200	0.15	3.3
- derv	520	0.60	3.0
Commerce and industry			
- coal			
- gas oil	250	0.25	0.6
- fuel oil	1000	0.025	0.3
	600	0.10	0.6

Table 1: Estimated smoke emissions in London from various sources in 1979/80 (10).

Source	Emissions 10^3 tonnes/annum
Coal	190
Smokeless fuel	17
Fuel oil	34
Gas oil	7
Motor spirit	30
Derv	122
Total	400

Table 2: UK emissions of black smoke in 1984 (13)

	Nationwide	Cities	Busy streets
Average concentration µg/m3	7	15	40
% attributable to:			
- all traffic	90	95	98
- diesels	80	90	95

Table 3: Calculated smoke concentrations in the Netherlands and the contribution of traffic (15)

Source and fuel type	Smoke emission 10^3 tonnes (from Table 1)	Approximate soiling factor relative to coal	Relative soiling index (%)
Domestic			
- coal	1.8	1	11
- smokeless fuel	2.0	1	13
Vehicles			
- petrol	3.3	0.43	9
- diesel	3.0	3	58
Commerce and industry			
- coal	0.6	1	4
- gas oil	0.3	1.55	3
- fuel oil	0.6	0.43	2

Table 4: Estimated soiling propensity of various fuel combustion sources in London in 1979/80. The soiling factors were provided by WSL.

Year of standard	g/BHP-hour
current	0.7
1988	0.6
1991	0.25
1994*	0.10

Table 5: Heavy-duty diesel particulate emission standards for the USA, expressed in grams per brake horsepower hour (30).
*The 1994 standard will apply for buses in 1991.

nsca

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BLACKPOOL

NOISE IN FLAT CONVERSIONS

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INTRODUCTION

In recent years there has been an increased tendency for many large older dwellings to be converted to form a number of self-contained flats or dwelling units; this trend to provide small units of accommodation is expected to continue. Several Local Authorities positively encourage this type of property conversion in order to supply a local need for single or small unit accommodation - indeed this tendency is demand-led, with many Local Authorities having a high proportion of persons on current housing lists waiting for single or one bed accommodation. Tameside MBC report a figure of 72% in this category.

Environmental Health Officers, nationwide, receive many complaints from tenants living in converted flats alleging noise disturbance or nuisance resulting from poor sound insulation and it was to find out the scale of the problem that, in 1985, the National Society for Clean Air surveyed Local Authorities in England, Scotland and Wales to see how they perceived and reacted to these complaints. This survey came quickly on the heels of other organisations such as the Manchester Area Council for Clean Air and Noise Control who published a booklet on the subject in October 1984.

In one London Borough it was estimated that by 1981 there had been over 5,000 conversions, and the Borough assessed that this increase by about 150 per year.

The survey revealed that nearly 6,000 planning applications had been received, incorporating over 17,000 dwelling units, by the 89 Local Authorities responding. 42% of the Local

Authorities already attach sound insulation conditions to planning permissions and 20% of them had refused an application where it was felt that sound insulation would be inadequate.

Few Local Authorities (LAs) have had experience in dealing with planning appeals, and those which had been involved questioned the consistency of approach from the Minister concerned. Many LAs reported an increasing number of complaints relating to noise because of inadequate sound insulation in flat conversions, but surprisingly few initiated any form of action in response to these complaints.

Although the Building Regulations 1985 require new dwellings to meet requirements for adequate sound insulation against airborne and impact noise, there is no such requirement for conversions in England and Wales. In Scotland, the matter is somewhat different; Environmental Health Officers North of the Border are satisfied that flat conversions do fall within the Scottish Building Regulations and this has been accepted by Building Control Officers. Consequently, there has been no necessity to resort to planning measures to achieve acceptable standards of sound insulation for converted dwelling units.

It is the lack of required standards for the provision of sound insulation which results in situations arising where an individual or a family, even when conducting themselves in a totally reasonable way and at reasonable times, find themselves causing a noise nuisance to their neighbours.

It has been said many times in the past, but will suffer reiteration, that 'prevention' is better than 'cure' and no where is it better illustrated than in this area of work.

All conversions involve works of reconstruction; most, if not all, will require planning permission for a change of use and LAs have an opportunity at this stage to take preventative action in respect of noise annoyance through the granting or refusal of planning permission. By this means the sound insulation needs of new dwellings formed by conversion can be incorporated.

This paper identifies matters to take into account when flats are produced from larger premises, outlines action taken by Local Authorities in this area, looks at the practical methods people can take to prevent sound insulation problems and gives details of legal options for those cases where noise nuisance arises after conversion work has been completed.

PREVENTION

So far as preventative measures are concerned, early consideration of the problem is essential if the new dwelling unit is to have any chance of attaining the standards normally applicable to new build situations. Local Authority Planning Officers should encourage applicants to contact the Environmental Health Officer so that early dialogue can be achieved with all interested parties well before the submission of a planning application.

It is suggested that the following principles should be adopted by Local Authorities when considering planning applications for flat conversion.

1. The living environment of adjoining dwellings should not be allowed to deteriorate as a result of the conversion

and creation of new dwelling units.

It is essential to protect the residents of existing accommodation, which may be structurally attached to a new flat.

In this instance noise disturbance from new flats into existing dwellings via a party wall or floor can, in many cases, be avoided by good design.

It is usually unacceptable for a kitchen, lounge or living room to share a party division with a neighbouring bedroom. This is often considered where houses are divided horizontally but similar considerations also apply where there is an existing dwelling on the ground floor of a building and the first floor is to be converted to a flat.

There will, however, be cases where acceptable room arrangements cannot be achieved by design and there might well be a need sufficiently to improve sound insulation of division structures as to PRESERVE THE AMENITY OF EXISTING NEIGHBOURS.

2. Occupiers of the new flat should be able to carry on normal living without the worry of creating a noise disturbance to neighbours in adjoining flats

Here the arrangement of rooms in the new flats should ensure that like room uses which are vertically or horizontally associated are compatible, eg the provision of bedrooms over living rooms of separate units should be avoided.

In the case of party walls between flats, developers should provide constructional details to ensure that the walls meet the

standards aimed at if the building regulations were to apply. The transmission of sound both through and along floors of flats should also be considered. Suitable resiliant floor coverings should be provided and maintained in good condition for all common parts of flats, eg halls, staircases etc. The sound of children running up or down untreated stairs can be particularly irritating.

3. New residential accommodation should be protected from external noise sources

External noise sources can include adjoining industrial, commercial and entertainment uses whether or not they are in an attached building, and transportation sources such as road, rail or aircraft.

It may be that where a manufacturing or entertainment type use exists in a structurally attached building, it is likely that noise problems will occur and there might be no practicable remedy for those occupiers of the new flat units. Here refusal is the answer. All mixed housing with industry/commerce situations requires careful consideration before a decision is made on a planning application and each case needs to be considered on its merits. Nevertheless, the principle of 'linked occupancy' should not be overlooked (eg in the case of a ground floor launderette and first floor flat a condition to require the same occupancy for both users could be imposed).

In all cases where larger buildings are to be converted to provide smaller dwelling units careful consideration should be given to potential noise problems.

In extremely difficult cases where problems of

shared use of buildings (eg industry with residential) suggests a likelihood of noise problems then, generally, refusal of planning permission is the recommended course of action.

An alternative to this may include granting conditional planning permission requiring the incompatible use to have ceased before the development of residential accommodation commences. (See Grampion Regional Council and Another v. City of Aberdeen District Council - December 1983).

Where other external noise sources such as industry, commerce and transportation are likely to cause problems the principles contained in DOE Circular 1/85 should be applied so that the new dwelling units can be upgraded as necessary to allow for satisfactory future occupation.

Notwithstanding the above, it is vital that when applications for flat conversions are considered any subsequent approval should require the incorporation of sound insulation techniques into the schedule of works so that the new occupiers and their neighbours can enjoy environmental acoustic protection equivalent to that already enjoyed by residents of 'new build' conventional housing and to ensure that as far as possible, flat dwellers do not suffer from noise stress in their homes.

Noise has long been recognised as an unjustifiable interference with ordinary human comfort and well being and for many Environmental Health Officers working in the planning field, the principles detailed above have been part and parcel of their advice to planning colleagues for several years.

There are a number of options open to the Local

Authority on the wording of conditions and the NSCA survey highlighted the following conditions in current use by Local Authorities.

(This is merely a list of conditions supplied by various Local Authorities and it is recognised that some would not comply with DOE Circular 1/85 or provide a proper answer to sound insulation problems).

(a) To BRE TIL 68 standard for floors
To BRE TIL 42 standard for walls.

(b) Requirement that party walls should comply with building regulation requirements.

(c) Requirement that internal layout should avoid juxtaposition of rooms of dissimilar use, ie units should be 'stacked' to minimise disturbance.

(d) To BS Code of Practice Grade 1 standard for floors and ceilings.

(e) Standard of 47 dB for floors
Standard of 49 dB for walls
(between residential units averaged over a frequency range of 100 to 3150 Hz)

(f) Provision of independent 25 mm plasterboard leaf with 25 mm absorbent quilt.

(g) Sand plugging and fibreglass quilt over joists with sheet polystyrene.

(h) For walls between living rooms and bedrooms, 50mm glass/mineral wool quilt faced with 9.5 mm plasterboard/plywood/chipboard/blockboard. For first floors and staircases 4.5 mm thickness rubber/sponge underlay covered by

carpet/lino or 8 mm thickness of cork tiles.

(N.B. The local authority building control offices have no power to enforce the floor covering conditions.)

The following condition is felt to be worthy of inclusion, in so much as the 'Best Practicable Means' approach can be used in any given situation:

> No development shall take place unless and until a scheme to soundproof the party wall/floor between the units has been submitted to and approved by the local Planning Authority and such works that form part of the approved scheme shall be completed before the flat is occupied.

It is interesting to note the reasons given by Local Authorities for NOT imposing sound insulation and conditions:-

(1) 18 Authorities considered sound insulation to be outside the scope of the Planning Department.
(2) 6 Authorities expressed doubts regarding practical and legal problems.
(3) 1 Authority felt the process too expensive.
(4) 1 Authority has a policy encouraging flat conversions to provide small dwellings.
(5) 3 Authorities stated that their Environmental Health Department was not consulted by the Planning Department.
(6) Seveal Authorities reported the lack of complaints regarding noise disturbance as a reason for not imposing conditions.
(7) Situation under review - 3 Authorities.

Local Authorities appear to be as confused as the DOE itself. The author can well understand

the doubts concerning the scope of planning legislation, particularly when one examines the differing views from the Secretary of State when considering appeals, but an active policy of encouraging flat conversions should not allow for the provision of sub-standard potentially 'unfit' dwellings.

The NSCA survey revealed that there is a REAL problem concerning inadequate sound insulation of converted dwellings and that an alteration to the current Building Regulations to encompass flat conversions as if they were new buildings, is the best way of ensuring satisfactory sound insulation, but as a less satisfactory alternative, Local Authorities should use the advice contained in Circular 1/85 to impose suitable conditions to a planning approval.

During the past few years several forward-looking Authorities have taken this route, only to be faced with the applicant submitting an appeal to the DOE. Unfortunately, the Secretary of State has, to say the least, handed down conflicting rulings which resulted in other Local Authorities doubting the validity of imposing conditions or refusing applications.

It was felt by many Environmental Health Officers that the only way forward was to continue to impose suitable conditions and wait until some Authority was brave enough to challenge an appeal decision and take the issue to the House of Lords. Fortunately for us the London Borough of Newham did not take long responding and their recent action, London Borough of Newham v. the Secretary of State for the Environment and East London Housing Association Limited, proved a classic case and confirmed the view that the likelihood of noise

being emitted from flat conversion is a material consideration for planning purposes (see the speech of Lord Scarman in Westminster City Council v. Great Portland Estates PLC (1985) IAC661 at 670) and consequently that Circular 1/85 should be taken into account when considering planning applications of this type.

This judgement now appears to be final and it is hoped that all Local Authorities will now reconsider their views with regard to flat conversions and accept and implement the principles in this paper.

So far as enforcement is concerned, it is the duty of a Local Authority to ensure that environmenal considerations are expressed as conditions to planning approval, and it is also obliged to confirm, where expedient, that conditions are implemented. It is, therefore, necessary to provide the Environmental Health Department with the right expertise within its department and the resources to check on work in progress. The resources in both manpower and equipment can be substantial if proper acoustic measurements are to be taken afterwards. One London Borough stopped visiting properties because it was considered too time-consuming but conditions are now enforced through local land searches.

However, in view of the acute housing shortage, it would be unfortunate if applications are turned down either because local authority's standards are too rigid or because sufficient manpower or equipment cannot be channelled into this area of work.

So much for preventative action, but what can people do if they live in flats that have not been upgraded acoustically and who suffer noise problems because of poor wall and floor

insulation?

It is interesting to note that the Noise Advisory Council stated in 1980

> "the Council's considered view is that dwellings which are subject to very high levels of noise are, in effect, unfit for occupation and should be brought up toa reasonable standard through noise insulation".

It is likely that anyone subjected to a noise nuisance will seek advice from the Local Authority through their local Councillor, or by complaining to their Environmental Health Officer. It is to be hoped that 12 years after reorganisation members of the general public feel happy to approach either elected member or an officer to report their complaints.

When a complaint is received an investigation should be instituted by the Local Authority's Environmental Health Officer. Any action adopted in pursuance of his investigation would be taken under the Control of Pollution Act 1974.

CONTROL OF POLLUTION ACT 1974

Part III of this Act (COPA) enables summary proceedings to be taken to deal with noise nuisance.

Section 58 of COPA places a duty on a Local Authority to serve Notice where it is satisfied that noise amounting to a nuisance exists, or is likely to occur or recur.

The Notice may impose all or any of the following requirements:

(a) requiring the abatement of nuisance or prohibiting or restricting its occurrence

or recurrence;

(b) requiring the execution of such works and the taking of such other steps as may be necessary for the purpose of the Notice or as may be specified on the Notice. The Notice must specify the time or times within which its requirements must be complied with.

Action is taken against the person responsible for the nuisance - the landlord or freeholder - and if the requirements of the Notice are not complied with, an offence will have occurred. The Magistrates Court can then institute a fine for non-compliance; alternatively, the Local Authority can carry out the necessary works to abate the nuisance in default.

However, this procedure does not allow for the granting of damages. It should be noted that Local Authorities have a duty both to inspect for nuisance (section 57) and to take prescribed action if a nuisance exists. Failure to do so could result in a legal claim against them or a complaint of maladministration being made to the Ombudsman. The latter was successfully pursued by a Tenant's Association against L.B. of Southwark in 1981 and against Wokingham District Council in 1985.

The City of Glasgow have used section 58 procedure successfully to abate noise nuisances occurring as a result of unsatisfactory sound insulation flats within its area. Complaints to their Environmental Health Department have revealed a wide range of social problems as a result of noise disturbance. Occupiers have claimed that their marriages have collapsed because they were aware their every move could be heard next door. More than one person described the situation as "living in a

pressure cooker".

Experience in Glasgow tends to support the view, first mooted in a Building Research Station paper in 1982, that the lack of proper sound insulation in tenement flats is considered by occupiers to be a bigger problem than condensation. The majority of Notices hve been served on Housing Associations which, because of their funding by Housing Corporations, has created some financial difficulties. To date there have been no appeals. This type of dwelling unit usually has a ceiling height of between 10 and 12 ft and conventional floor treatments have provided a satisfactory answer in most cases.

(Interesting cases include:- A. Lambert Flat Management Limited v. Lomas - All England Law Reports (1981) 2 All ER).

In particular cases it may be possible for the freeholder to recover from the leaseholder the costs of any works carried out (and the leaseholder may himself be the complainant). In these cases Common Law action for damages taken in tandem with COPA action may be the solution.

For Local Authority tenants section 58 is not available as the Local Authority cannot serve Notice on themselves; then, section 59 of COPA becomes the only remedy. It is good to note that some Local Authorities recognise their responsibility in this field and have adopted a policy of providing effective sound insulation in their own flat conversions.

S. 59 provides similar action as s.58, except that in this case a Magistrates Court may act on a complaint made by the occupier of any premises on the grounds that in his capacity as occupier of the premises he is aggrieved by

noise amounting to a nuisance.

A recent case taken under s.59 of COPA is worthy of note:-

Silvia Rossell, a tenant of a Council-owned basement flat, claimed that she was disturbed by intrusive noise from the upstairs flat, covering anything from television to her neighbour's lovemaking. The owners, the London Borough of Southwark, apparently felt that the activities of the upstairs tenants were nothing out of the ordinary and the nuisance arose from the lack of suitable sound insulation. The Council, on advice, pleaded guilty and the Magistrates awarded costs of £715.74p and made a Court Order which made it clear that the Council was held liable as being "responsible" for the noise nuisance - as well as being the owner; Southwark were given 12 weeks to erect an independent ceiling. The NSCA survey revealed that Southwark receives "hundreds of complaints each year" about noise due to poor insulation. It may not be coincidence that the Borough's decision not to defend the case came at a time when it was seeking action against a private owner on account of deficient sound insulation.

COMMON LAW

It has long been established practice in Britain for noise to be considered the subject of an activity which unduly or unreasonably interferes with an individual's rights, use, or enjoyment of land. If it can be shown that the disturbance caused by the noise substantially affects health, comfort, or convenience, a Court may grant damages, or an injunction, or both; best practicable means is no defence in this case.

The recent case of SAMPSON v. HODSON-PRESSINGER and another is interesting to note.

In this instance a building had been converted into flats with a roof terrace constructed above the Plaintiff's sitting room, kitchen and bathroom. French windows had been put in a wall of the sitting room of another flat (flat 7) so that it opened onto the terrace. The Plaintiff had taken out a lease, which contained the usual covenant for quiet enjoyment, in March 1978. In August 1978 the first defendant moved into flat 7 under a similar lease and proceeded to use the roof terrace in a normal way, occasionally having parties.

However, because the tiles had been improperly laid, the noise of treading feet penetrated into the flat below and the Plaintiff could also hear ordinary speech to such an extent that it interfered with the use and enjoyment of his premises. He, therefore, complained to the occupier of Flat 7 and to the Landlord. In May 1979 the second defendant showed an interest in buying the freehold of the entire house. The Plaintiff informed him of the noise nuisance from the terrace and showed him an Architect's report in which the noise was described as excessive and in which certain remedies were suggested. However, the second defendant purchased the property, but afterwards denied any responsibility for the noise nuisance. The Plaintiff thereafter brought an action against the new owner claiming damages against him and further seeking an injunction against both defendants to restrain them from causing or permitting the terrace to be used in such a manner as to cause nuisance.

The judge awarded the Plaintiff £2,000 damages

against the second defendant, but refused an injunction. The second defendant appealed, contending that he could not be liable in nuisance because the first defendant was using the property in a normal manner and that, even though the original landlord might be liable, he was not because he was not responsible for the construction of the roof terrace and was unable to control the use of it by the first defendant.

It was held that:-

1. Although the new landlord was not responsible for the construction of the roof terrace he WAS LIABLE for the nuisance created by its use, because when he bought the premises he was aware that use of the terrace would cause disturbance to the Plaintiff.

However, he was liable in nuisance notwithstanding that the first defendant was using the residence in a normal way because the property itself was NOT FIT to be used in a normal way, so far as the terrace was concerned, without interfering with the reasonable enjoyment by the Plaintiff of his flat. Accordingly, the second defendant (owner) was liable in nuisance and for breach of the covenant for quiet enjoyment.

2. It was appropriate in this case to award damages in lieu of an injunction since they would produce a satisfactory result and achieve finality and were not against the will of the plaintiff. The award of damages against the second defendant would stand and the appeal was dismissed.

It is interesting to note that the award of damages of £2,000 (equivalent to £3,500 in

present day terms) was probably more than the cost of carrying out the remedial works.

DEFECTIVE PREMISES ACT 1972

Section 1 of this little known Act imposes a duty on anyone building a new dwelling to see that the work is carried out in a workmanlike and professional manner, using proper materials so that the end result will be a dwelling fit for human habitation. The duty is not affected by subsequent sale of the premises and applies to all forms of tenancy: there can be no agreement to contract out.

Claims for damages may be made against the landlord, if he hs the duty, or against third parties including the builder or architect. Where it can be shown that unsatisfactory sound insulation has resulted because of improper materials or poor workmanship a claim for damages could be made against the person responsible for the works.

However action must be started within 6 years of the dwelling of conversion being completed.

CONCLUSIONS

1. The problem of noise nuisance occurring in converted dwellings is very real, and increasing year by year. Frequently a problem only shows itself when a change in occupancy occurs, and where a quiet individual living in a converted flat is replaced by an ordinary family, who inevitably create noise disturbance if the sound insulation is of poor quality.

2. It is of prime importance that the English/Welsh Building Regulations 1985 are modified as soon as possible to require

that adequate attention is paid to sound insulation in converted dwellings. The situation in Scotland, where the Building Regulations do apply to conversions, shows that in many cases the problem can be prevented by the inclusion of a Best Practicable Means approach to sound insulation.

3. In the interim period the DOE should immediately publish proper guidance to Local Planning Authorities, stating that sound insulation is a material planning consideration and advising on acceptable draft conditions which could be included in any subsequent planning approvals.

4. Local Authorities should appoint Environmental Health Officers (with appropriate acoustic qualification and experience) to undertake investigations on receipt of a complaint from an occupier of a dwelling suffering from noise nuisance due to inadequate sound insulation. The Local Authority should also make available the necessary financial resources to provide the equipment in order to ensure that proper acoustic measurements are taken. The same consideration will apply when planning conditions are imposed which require subsequent inspection and enforcement.

5. Local Authorities should establish a policy to improve the sound insulation in their own converted dwellings to match a 'new build' situation.

6. There is adequate evidence that 'text book' specifications for improving sound insulation in a converted dwelling do work in a very high proportion of situations

and, further, that the cost of remedial works usually significantly exceeds the cost of installing sound insulation at the time of conversion.

REFERENCES

1. Circular 10/73. Planning and Noise. DOE HMSO 1973.
2. Circular 1/85. The Use of Conditions in Planning Permissions. DOE HMSO 1985.
3. The Manchester Area Council for Clean Air and Noise Control. Planning guidance for sound insulation of flats formed by conversion. October 1984.
4. S. Rintoul. Some economic and legal considerations of improving the sound insulation of party floors in converted dwellings. Proceedings of the Institute of Acoustics, Vol. 8 Part 1 pp 1-90 (1986).
5. J.A. Blair. City of Glasgow District Council - verbal communication (with thanks).
6. The Noise Advisory Council. A Study of Government Noise Insulation Policies. HMSO 1980.
7. Current Law Reports. October (1985) IOCL.
8. National Society for Clean Air. Report on Sound Insulation in flat conversions, Part 1, Outline of the Problems and NSCA survey results. NSCA Noise Committee. June 1986.
9. James A. Blair. An experience in extensive sound testing and enforcement. Proceedings of the Institute of Acoustics Vol. 8 Part 1 pp 1-9 (1986).
10. Building Standards (Scotland) (Consolidation) Regulations 1971 Part H "Resistance to the Transmission of Sound" HMSO
11. The Building Regulations 1985. HMSO.
12. The Town and Country Planning Act 1971. HMSO.
13. Control of Pollution Act 1974. HMSO.
14. Sampson v. Hodson-Pressinger and Another. All England Law Reports (1981) 3 All ER.
15. Building Research Advisory Service TIL 68 October 1982 (Crown Copyright) TIL 42

October 1982 (Crown Copyright)
16. F.J. Langdon, I.B. Buller and W.W. Scholes. Noise from neighbours and the sound insulation of party floors and walls in flats. Journal of Sound and Vibration; (1983) 88(2), 243-270.
17. Defective Premises Act 1972 Chapter 35. HMSO.

SUGGESTED FURTHER READING

1. S.W. Turner. Insulation of floors in converted dwellings against sound transmission. Scientific Services Branch GLC ISSN 0264 - 7524 - Summer 1983.
2. W.A. Utley. Methods for improving the sound insulation of existing simple wood joist floors. Building Research Establishment CP.27/77.
3. Building Research Establishment Digest. Sound insulation of party walls. Digest 252 August 1981; Sound Insulation of party floors. Digest 266; Sound insulation: basic principles. Digest 143; sound insulation of lightweight dwellings. Digest 187.
4. Methods of Measurement of sound insulation in buildings and of building elements. BS.2750: Part 4 1980 - 150 140/IV - 1978. British Standards Institution.
5. Intermediate timber floors in converted dwellings. Defect action sheet DAS 45 BRE.
6. L.C. Fothgill. Case studies of attempts to improve the sound insulation between dwellings. Applied acoustics 13 (1980) 291-311.
7. Tegwyn Jones. Sound insulation of party floors. Yeovil District Council, January 1985.
8. Rating of Sound insulation in Buildings and of Building Elements. B.S. 5821: 1984 B.S.I.

AUTHOR'S NOTE

The views expressed in this paper should be taken as those of the Author and do not necessarily represent the views of the Author's employers or any other organisation with which the Author is associated.

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ALTERNATIVE NOISE ABATEMENT ZONES

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1. INTRODUCTION

One of the major criticisms voiced by the Noise Advisory Council in their report, 'Neighbourhood Noise', which was published in 1971, was the 'nuisance' approach employed by Local Authorities for the control of industrial and commercial noise. This method of working meant that action was not taken by the Local Authorities unless it could be shown that the noise amounted to a nuisance. The Council considered, and quite rightly, that if such an approach to noise control were employed, then, provided individual increases in noise were in the 'sub-nuisance' class, there was nothing to prevent a 'creeping deterioration' in the overall noise climate of a neighbourhood.

It was recognised by the Council that this method of working was dictated by the legislation then available to local authorities for noise control, and it therefore suggested that further legislative controls be provided to enable the Local Authorities to take positive action to combat the 'creeping deterioration'. Support for the Noise Advisory Council's proposals was offered by the then Association of Public Health Inspectors, who also supported a subsequent report which emphasised the need to plan industrial development so as to minimise the effects of any associated noise.

It seems that these reports were read by the right people, because both the planning and control concepts were subsequently embodied in Control of Pollution Act 1974, which gave Local Authorities the power to declare Noise Abatement Zones.

As originally envisaged, the Noise Abatement

Zone was to provide what was almost an acoustic equivalent of the Smoke Control Area - it was to be an area in which noise from premises was to be controlled and, further, which would not be subject to creeping background noise levels. In more formal terms, it was to be an area defined by the Local Authority, wherein the noise emission from relevant premises had been measured and recorded in the Noise Level Register. Those recorded noise levels were not thereafter to be exceeded without the consent of the Local Authority.

With these requirements in mind, legislation was framed which would allow Local Authorities to establish Noise Abatement Zones within their districts and Section 57(b) of the Control of Pollution Act 1974 advises Local Authorities that 'it shall be the duty of any local authority to cause its area to be inspected from time to time, to decide how to exercise its powers concerning Noise Abatement Zones'.

The relevant sections of the Control of Pollution Act 1974, and the associated guidance notes, detail a comprehensive procedure dealing with all aspects of the Noise Abatement Zone, from its initial selection to the method of measurement and the layout of the Noise Level Register.

2. THE LEGISLATION

Sections 63-67 of the Control of Pollution Act 1974 set out the Local Authority's powers in respect of Noise Abatement Zones, and make interesting reading, if only because they represent such a radical departure from the philosophy of previous noise control legislation, and indeed, from the remainder of Part III of the Control of Pollution Act 1974.

Section 63 and 64 refer to the declaration of the Noise Abatement Zone and to the keeping of the Noise Level Register. The real power of the legislation is, however, contained in Sections 65, 66 and 67 of the Act.

Section 65 deals with 'noise exceeding the registered level' and makes it an offence to permit noise in excess of that recorded in the Noise Level Register to be emitted from premises to which a Noise Abatement Order applies.

Section 68 empowers the Local Authority to serve a noise reduction notice on the person responsible, when it is satisfied -

"a) that the level of noise emanating from any premises to which a Noise Abatement Order applies is not acceptable, having regard for the purposes for which the Order was made, and

b) that the reduction in level is practicable at reasonable cost and would afford a public benefit".

Although this section of the Act still permits a trade or business to employ the defence that the best practicable means have been used for preventing or counteracting the effect of the noise, it is unusual in that it permits the local authority to require the reduction of noise that does not amount to a nuisance.

Section 67 applies to new buildings within an existing Noise Abatement Zone and allows the local authority to determine noise levels in the case of such new buildings as are subject to the Noise Abatement Order. When the owner or occupier of such a building does not apply to the Local Authority (LA) to have the noise levels for the building determined, then the LA can require the reduction of noise levels

without being satisfied that the reduction is practicable at reasonable cost and would afford public benefit. Furthermore, such a noise reduction notice may require the noise level to be reduced in three months instead of six and the 'best practicable means' defence is no longer available for noise associated with a trade or industry.

There is, therefore, considerable incentive for persons intending to alter or construct premises in an existing noise abatement zone to apply for a determination of noise levels.

3. TRADITIONAL NOISE ABATEMENT ZONES

Recognising both the unique advantages conferred by the legislation and the environmental improvements which could be derived from the application of Noise Abatement Zones, some of the larger LAs took up the idea with great enthusiasm and embarked on programmes which would ultimately have made the entire local authority area a Noise Abatement Zone. Others, short as usual on staff and resources, approached the matter with more caution and established small, often single premises, Noise Abatement Zones. All, however, who became involved in the setting up of Noise Abatement Zones, rapidly came to realise that these projects were almost a bottomless pit into which manpower and resources could disappear, virtually without trace. Furthermore, it soon became apparent that unless an equivalent input of manpower and resources could be maintained on a regular basis, then the Noise Abatement Zone was of little practical value for noise control purposes. The reason for this heavy commitment of staff and resources is illustrated by the example which follows.

Suppose, for instance, that a local authority, in order to control noise emission and prevent background creep, has decided to designate as a Noise Abatement Zone a small industrial estate containing ten factory buildings which is situated on the edge of a residential area (see Fig. 1).

Firstly, it is necessary to set out noise control boundaries, enclosing each of the ten factory buildings. The measurement points should then be determined in accordance with the guidance given in the Control of Noise (Measurement and Registers) Regulations 1976. The number and location of the measurement points will depend on the size and configuration of the factory building but, for the average small factory, a minimum of about twelve measuring positions would seem to be needed.

Measurements can now be carried out at each of the measurement points. The object of this exercise is to determine the level of noise emitted from the premises throughout a representative 24 hour period. Thus, measurements will have to be made to cover daytime, evening and night-time emission from the premises. The duration of these measurements will depend on the nature of the noise; for a steady noise level, a 15 minute measurement may well be sufficient; but if the noise is of an irregular or varying nature, it may well be necessary to determine the Equivalent Continuous Noise Level (Leq) for the entire period in question. The duration of the time spent in measurement is therefore totally dependent on the nature and character of the noise being measured. For the purpose of this exercise it has been assumed that the average measuring period is 20 minutes. This figure does not, however, take into account the total

time spent at each measurement point. Time will also be needed for the setting up and calibration of the instrument, and account must also be taken for the time needed to move from one measurement point to the next. It does not, therefore, seem unreasonable to suggest that, on average, a maximum of two measurements could be completed every hour. Thus, for the proposed 10-premises Noise Abatement Zone, the total measuring time will be in the order of 180 hours $\frac{(10 \times 12 \times 3)}{2}$. Assuming that the person carrying out the measurements can work on site for 6 hrs/day, the initial series of measurements can theoretically be accomplished in 30 days. It must, however, be remembered that, according to the Regulations, measurements must not be made in conditions of rain, snow, fog or high winds. So, in real terms, this initial phase of the measurements could take up to three months to accomplish.

The procedure laid out above is very theoretical and ignores a number of important practical points. First, it assumes that the processes giving rise to the noise emitted from the factory are subject to regular usage. It does not appear to allow for the fact that, particularly in small factories, certain processes may only be used on an intermittent basis, as and when they are required. For instance, in a factory concerned with the fabrication of structural steelwork, the noisy process of grinding down welds may only take place for one day in ten; for the rest of the time the noise will be of the much lower level associated with the drilling, welding and cutting operations involved with the fabrication process. Thus, unless the measurements are made on the day on which the grinding operation takes place, the noise levels recorded in the register will be much lower than the actual maximum for the premises.

This effect of varying process noise can also occur during the day and may result in widely varying levels at adjacent measuring positions. Once again, a totally false impression of the level of noise emission from the premises may be recorded in the register.

It can be argued that these difficulties could be overcome by arranging with the factory manager that a representative sample of work is carried out during the measurement period. However, the weakness of this system is that management is allowed to decide what is a representative sample and this may well result in higher than usual levels of noise emission from the premises.

Another failing of the method of assessment is that there is no simple way of taking into account the contribution due to noise from adjacent premises. For instance, how is it possible when measuring the noise from factory A, to allow for noise from factory B? In theory, one could ask that factory B shuts down for the day, but such a suggestion is not likely to be well received.

The difficulties outlined above can eventually be overcome, by hard work, luck and cunning, and the Zone's Noise Level Register established. But in order to maintain the Noise Abatement Zone all these measurements will have to be repeated on a regular basis, at least once and ideally twice a year. Furthermore, when repeating the measurements it is necessary to ensure that conditions in the factory and externally are as nearly identical as possible as those which existed when the first measurements were being made. Thus, the second series of measurements could well take significantly longer to obtain than the first

series! Therefore, it does not seen unreasonable to suggest that this small Abatement Zone could well involve an expenditure in staff time, for the measurements alone, of some 400 man hours per year and that this, in real terms, might amount to six months' work for one member of staff and the necessary instrumentation.

Such heavy expenditure of manpower resources could, perhaps, be justified, if it provided the solution to an exceptional noise problem; but if it does not, the public will, by and large, experience little benefit from most of the work which has gone into the establishment of this Noise Abatement Zone.

4. THE 'ALTERNATIVE' NOISE ABATEMENT ZONE

If used in the manner illustrated in the preceding example, Noise Abatement Zones provide a very precise and powerful means of controlling noise from classified premises, and there are undoubtedly particular circumstances where the high level of expenditure and resource commitment can be justified. However, in 'normal' circumstances, and ironically, for the very purpose for which Noise Abatement Zones were first envisaged - the control of background noise creep - the traditional Noise Abatement Zone can no longer be considered cost effective, and for this reason, no longer represents a viable, economic option for most Local Authorities.

It is, however, considered by the author and by other members of the Society's Noise Committee, that Noise Abatement Zones can be used in a way which is cost effective and which still confers upon the Local Authority the considerable advantages of the legislation.

It will be apparent from part 3 of this paper that the cost/resource implications of a Noise Abatement Zone are purely a function of the number of measurement points which have been employed. It would, therefore, seem reasonable to assume that if the number of measurement points can be reduced, then the cost of setting up and operating the Noise Abatement Zone will be less.

Guidance as to the number of measurement points needed for a Noise Abatement Zone is given in the 'Memorandum on Measurement and Calculation of Noise Levels' contained in the Schedule of 'The Control of Noise (Measurement and Registers) Regulations 1976'.

Paragraph 2(1) of the memorandum states "Noise emanating from classified premises in a noise abatement zone should be measured at points on a line drawn so as to enclose all significant noise sources on the premises" and, para. 3(1), "The number and position of measurement points will be dictated by the degree of control proposed to be exercised over the level of noise from any premises". Paragraph 3(1) goes on to suggest that the most complete control will be obtained by adopting the 'equal angle' approach illustrated in Figure 1 of the Regulations. The use of the 'equal angle' approach for setting out the measurement positions is illustrated in Figure 2 of the Regulations, this figure being reproduced as Figure 2 of this paper.

The degree of coverage - and hence control - illustrated in Figure 2 is, however, only necessary in a very limited number of cases; perhaps, for instance, where the industrial premises are surrounded by residential property and where the processes carried out on the site are known to give rise to high levels of noise.

In many cases, for example in the situation shown in Figure 1, this level of control is totally unnecessary. If, for instance, there are only a limited number of noise sources within the site, and/or the processes involved are not excessively noisy and are unlikely to change, then measurement points need only be located on the 'sensitive sections' of the noise control boundary between the noise sources and the residential property. Furthermore, the numer of measurement points need only be sufficient to provide for the monitoring of existing noise sources. After all, if in the future the level of activity on the site is increased and extra noise sources become operational, then extra measurement points can be introduced as required, and as the Noise Abatement Zone is already in existence, notices can, if necessary, be served under Section 66 of the Control of Pollution Act 1974, requiring that the levels of emission from the new noise sources be reduced.

If this philosophy were to be adopted, it would seem both practical and permissible to declare Noise Abatement Zones wherein the number of measurement points per classified premises was the absolute minimum needed to provide the required level of control, and further, where those measurement points were located only on the sensitive section of the noise control boundary. If this aproach were applied to the hypothetical Noise Abatement Zone illustrated in Figure 1, then as is shown in Figure 3, the number of measurement points could be greatly reduced and the cost of setting up and maintaining the Zone would be proportionally less.

Noise Abatement Zones of this type could be employed to protect residential areas situated

on the boundary of an industrial area and would be of particular value in redevelopment areas where either the housing or the industry had recently been introduced into the area, and where consequently the Local Authority wishes to exercise close control over future noise levels. In such circumstances, it would seem advantageous to declare single premises Noise Abatement Zones (mini-zones) which would enclose only those industrial premises that were adjacent to the residential area, and to locate the measurement points only along that part of the noise control boundary which lay between the residential area and the industrial premises.

By using such a technique, it would be possible to establish a legally enforceable limit to the level of noise emission from the industrial premises adjacent to the residential property. Furthermore, this method is not dependent (as in action under Section 58 of the Control of Pollution Act 1974) upon the need to show that the level of noise emitted from the factory is sufficient to constitute a statutory nuisance. It can therefore be imposed upon the factory as soon as it is occupied, and thereafter the premises are subject to the controls laid down in Sections 63-67 of the Control of Pollution Act 1974. A certain level of investment in terms of staff time is, of course, needed to establish and maintain the mini-zones, but this is not usually excessive and is, in any case, more justifiable in that it is positively protecting the public from noise.

The technique outlined above may not be that which was envisaged when the Noise Abatement Zone legislation was first drafted, but it works, it provides a reasonable return on investment, and is therefore worthy of consideration.

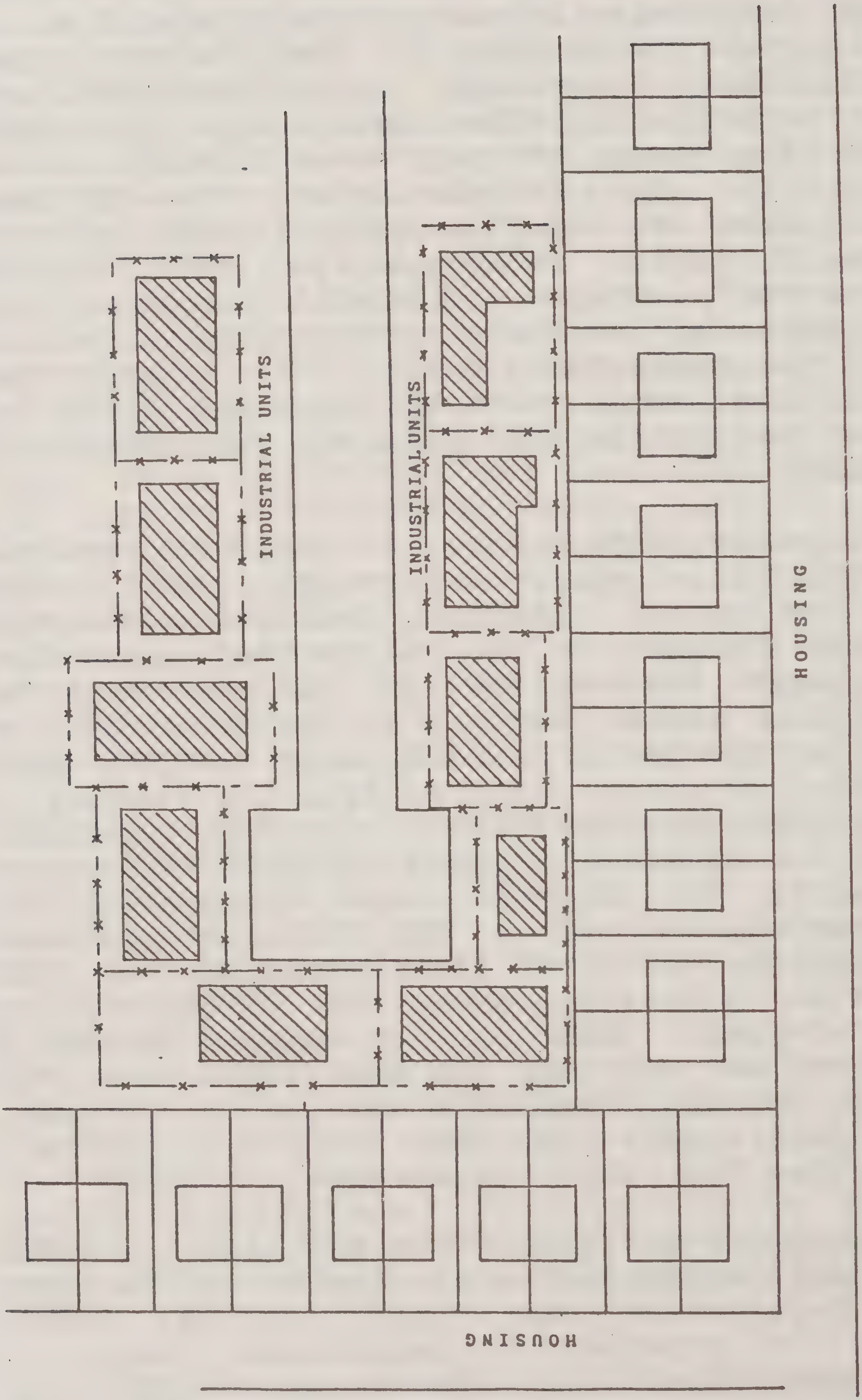

FIGURE 1: TRADITIONAL NOISE ABATEMENT ZONES
(– x – Denotes Noise Control Boundary and Measurement Points)

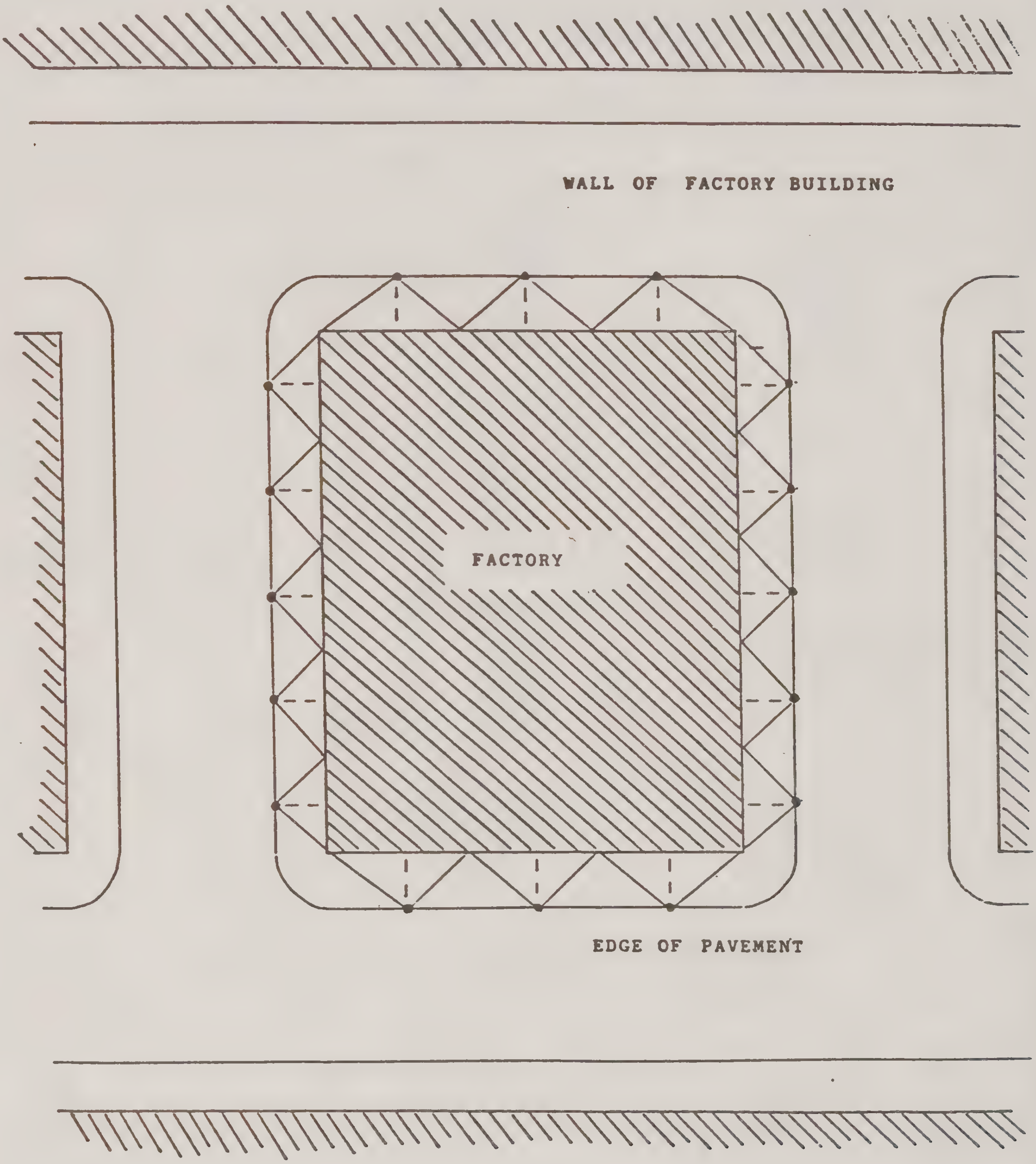

FIGURE 2: EQUAL ANGLE METHOD FOR LOCATION OF MEASUREMENT POINTS

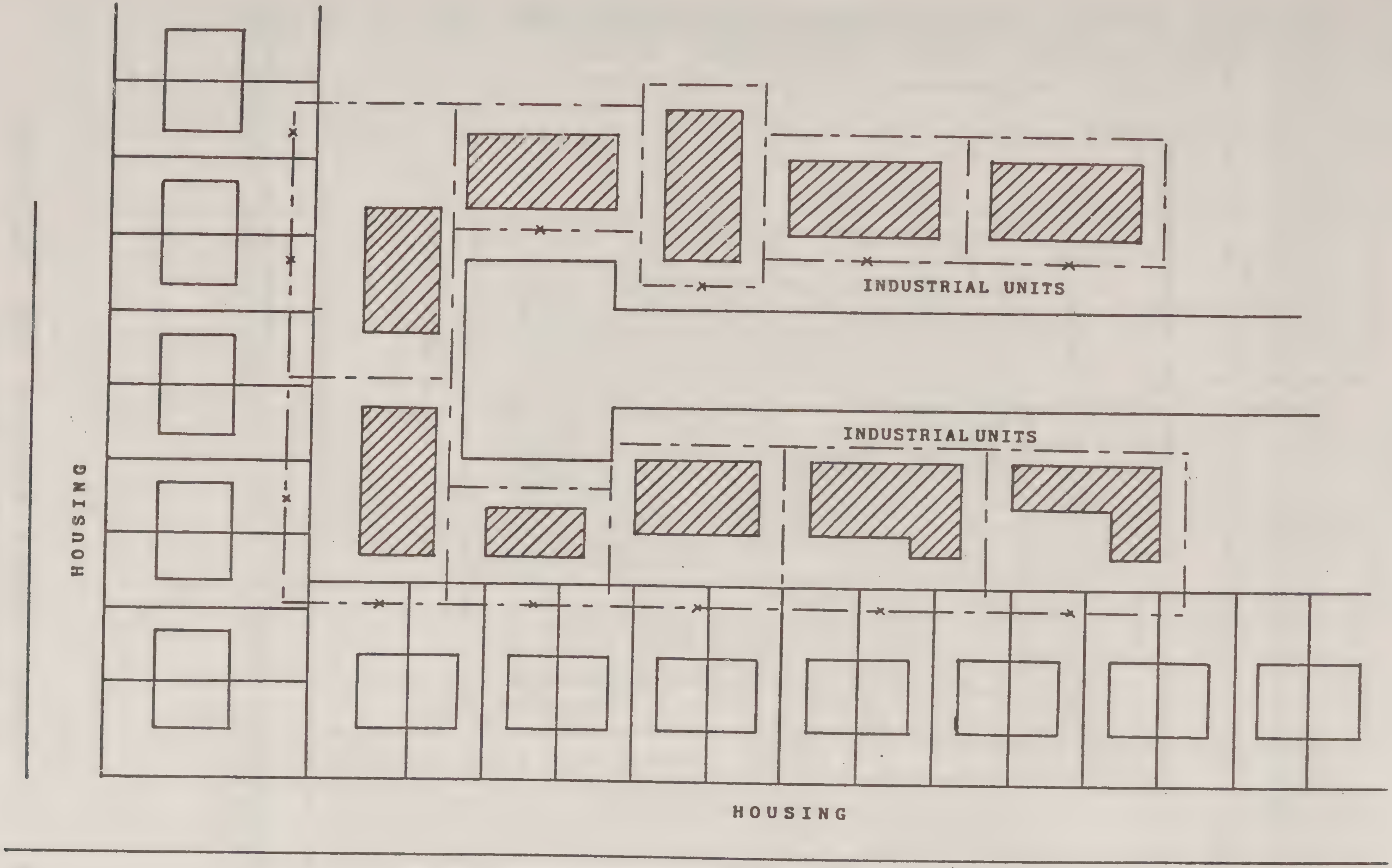

FIGURE 3: ALTERNATIVE NOISE ABATEMENT ZONES
(- x - Denotes Noise Control Boundary and Measurement Points)

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53rd ANNUAL CONFERENCE
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BLACKPOOL

MOTOR CYCLE NOISE

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MOTOR CYCLE NOISE

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When I was asked to present a paper on motor cycle noise in a short 15 minute slot I thought how difficult it would be to explain in a meaningful way the complex "Construction & Use" legislation and the reasons why the legislation is often impracticable to enforce. More importantly to discuss the consequent need for a change in the emphasis of control would again prove difficult.

It is my experience from attending meetings of the Manchester Area Council for Clean Air and Noise Control and the Derbyshire Advisory Council for Clean Air and Noise Control that elected members are becoming increasingly concerned about the number of motor cycle noise complaints they are receiving and the apparent difficulties and frequent frustration experienced by their Local Government Officers and Police Authorities at being unable in many instances to resolve problems. The problems range from the use of motor cycles on the public highway and housing estate roads to their use on private land. In order to meet the many enquiries from elected members it became necessary to produce a written assessment of the current situation and therefore a report was produced for the Manchester Area Council for Clean Air and Noise Control entitled "Motor Cycle Noise" (1) This Report has been introduced to the Noise Committee of the National Society for Clean Air and it gives a history of existing and proposed legislation, and a review of the current thinking on ways to obtain an improvement in the situation.

Given the limited time available this written paper, which draws extensively from the MACCANC document, is intended to provide a background to my presentation at Conference.

LEGISLATION

The principal legislation for the control of motor cycle noise is the Motor Vehicles (Construction & Use) Regulations 1978(2). As the title implies it is intended to control noise from motor cycles in two ways i.e. by limiting the noise from new motor cycles on or after various dates and the noise arising from their 'use' after manufacture.

"Construction Noise"

Regulation 31 controls the maximum noise level of an individual motor cycle first used on or after 1st April, 1970. This 'type approval' test must be carried out where the conditions and method of measurement are those specified in British Standard 3425.(3) and using equipment to comply with British Standard 3539.(4) The maximum noise levels are:-

Cylinder Capacity (cc)	Sound Level dBA
Up to 50	77
51 to 125	82
Above 125	86

Similarly Regulation 31B of these Regulations controls noise from individual motor cycles manufactured on or after 1st October 1982 and first used on or after 1st April, 1983. Regulation 31B refers to EEC Council Directive 78/1015(5) which additionally specifies the method of measurement and the equipment to be used.

The issue of a 'Type Approval' Certificate is provided for in the UK by the Motor Cycles (Sound Level Measurement Certificates) Regulations 1980 which requires satisfaction of an acceleration test and statement of both the

results of a stationary test and details of silencing provisions. The maximum noise levels for an acceleration drive-by test are:-

Cylinder Capacity (cc)	Sound Level dBA.
Up to 80	78
81 to 125	80
126 to 350	83
351 to 500	85
Over 500	86

Directive 78/1015 EEC required the Council to reduce the maximum permissible noise limits by the end of 1984 and Draft Directive 9148/84(6) is presently being considered by Member States. The Draft Directive proposes a two stage reduction in the maximum permissible sound levels from 1987 and 1995 and these are:-

Cylinder Capacity (cc)	Sound Level dBA. From 1/10/87	From 1/10/95
Up to 80	77	75
81 to 175	80	78
Over 175	82	80

The Draft Directive also proposes changes in the motor cycle operating parameters when noise level tests are carried out.

LEGISLATION COVERING 'USE' NOISE

Regulation 30 of the Motor Vehicles (Construction & Use) Regulations 1978 requires every motor cycle to be fitted with a silencer, expansion chamber or other contrivance suitable and sufficient for reducing as far as may be reasonable the noise caused by the escape of the exhaust gases from the engine.

Regulation 116A supplements Regulation 30 by requiring that no person shall use or cause or permit to be used on a road any motor cycle:-

a) such that exhaust gases escape to atmosphere without first passing through the silencer.
b) with a silencer altered or replaced such that the motor cycle fails to comply with the maximum permitted sound level of Regulation 31, or
c) with a silencer which is not in good and efficient working order.

Hence, whilst a new motor cycle when leaving its manufacturer will normally be fitted with an effective silencer, it may have a relatively short life. Concern over the adequacy of cheap replacements resulted, at the request of the Department of Transport, in the preparation of British Standard BSAU 193 (7) which specifies requirements for the silencing properties of replacement motor cycle and moped exhaust systems.

Regulation 116C supports this British Standard by providing that the silencer of any motor cycle, first used on a road after 1st January 1985, shall either be that with which the machine was fitted when it was first used, or be clearly and indelibly marked with either the appropriate British Standard marking or a reference to its make and type specified by the manufacturer of the motor cycle.

Thus it appears that Regulation 30 requires a silencer to be fitted to a motor cycle wherever it is, but Regulations 116A and 116C govern its use and condition only when the machine is on a road. In practice, however, enforcement of Regulationin the face of deliberate tampering with a silencer by an owner striving for a "sporty" noise is not straightforward.

Statistics for activity in enforcing vehicle noise regulations in 1983 are shown in Table 1,

from which it can be seen that the majority of prosecutions concern defective silencers.

LIMITATION OF "USE" NOISE BY MEASUREMENT

Regulation 116 of the Motor Vehicles (Construction and Use) Regulations 1978 applies to motor cycles first used on or after 1st January 1981, and specifies as below maximum permitted sound levels as measured under specified conditions when the machine is in use on a road:-

	Sound Level dBA		
Machine first used:	Before 1.11.70	1.11.70 to 31.3.83	After 31.3.83
Up to 50 cc	83	83	81
51 to 125 cc	90	85	83
Over 125 cc	90	89	89

In practice this Regulation is difficult to enforce due to conflict between the impracticable measurement conditions specified and the implication that the test must be carried out by the roadside.

Regulation 114 of the Motor Vehicles (Construction and Use) Regulations 1978 requires that no person shall use or cause or permit to be used on a road any motor cycle which causes excessive noise, while Regulation 115 demands that no motor cycle shall be used on a road in such a manner as to cause excessive noise which the driver could have avoided by the exercise of reasonable care.

At first sight these Regulations seem to be a useful means of controlling excessive motor cycle noise, although they relate only to the use of machines on the road. However, "excessive" is somewhat subjective; Regulation

116 seeks to be more objective, but suffers impracticability and it could reasonably be argued that noise is not "excessive" unless Regulation 116 is infringed. The status of the stationary noise test results of Regulation 31B appears uncertain.

THE CONTROL OF MOTOR CYCLE NOISE ON OPEN LAND

Section 36 of the Road Traffic Act 1972 prohibits the unauthorised driving of a motor vehicle on any common land, moorland or other land not forming part of a road, or on any road being a footpath or bridleway. It is not an offence to drive on land within 15 yards of a road for the sole purpose of parking.

This section would appear to be all embracing as regards the off-road use of motor cycles, with the police as the enforcing authority. However, in practice, the police have claimed difficulties in apprehending offenders on terrain which is unsuitable for their mobile officers.

Additionally, since by Section 190 of the Road Traffic Act 1972, "motor vehicle" (which has been taken to include a "motor cycle") is defined as a mechanically propelled vehicle intended or adapted for use on roads, there is some doubt as to whether a motor cycle not licensed for road use and used off roads constitutes a "motor vehicle". In Burns v. Currell (1963), Lord Parker stated that the test (in a case relating to a Go-Kart) was whether a reasonable man looking at the vehicle in question would say that one of its uses would be a use on the road. The applicability of the Road Traffic Act 1972 to unlicensed motor cycles appears to depend upon this interpretation.

Trials

Section 35 of the Road Traffic Act 1972 requires local authority authorisation for a motor cycle trial on a footpath or bridleway. Such authorisation is not to be given without the written consent of the owner and occupier of the land over which the footpath or bridleway runs.

"Trial" is not defined, but is understood to relate to an organised event rather than individuals riding motor cycles for enjoyment on land other than a road.

Byelaws

Section 235 of the Local Government Act 1972 enables a district council (or London Borough) to make byelaws for the prevention and suppression of nuisance within their area, such byelaws to be confirmed by the Secretary of State.

The London Borough of Barking and Dagenham has attempted to "plug the gap" in section 36 and 190 of the Road Traffic Act 1972 through the introduction in February 1982 of a byelaw prohibiting the riding, driving or operating of any motor bicycle .... not intended or adapted for use on roads .... on any open land in the Borough ...., subject upon summary conviction to a fine not exceeding £50. It is understood that two other London Boroughs (Redbridge and Havering) have introduced similar byelaws.

Section 58 of the Control of Pollution Act 1974 provides that where it is satisfied that noise amounting to a nuisance exists or is likely to occur or recur in its area, a local authority shall serve a notice requiring abatement of the nuisance. Since section 58 also requires that

the notice shall be served on either the person responsible for the nuisance or, if that person cannot be found or the nuisance has not yet occurred, the owner or occupier of the premises from which the noise is, or would be, emitted, its application to the off-road use of motor cycles would presumably be hampered by a need in practice to apprehend the rider. Noise arising from the sale, repair or testing of motor cycles at the premises of a motor cycle trader may well be more readily actionable by a local authority.

CURRENT VIEW OF THE PROBLEM

Both national surveys and the survey carried out by the Manchester Area Council for Clean Air & Noise Control have shown that motor cycle noise figures significantly in causing annoyance and disturbance particularly in the more urban areas not heavily congested with traffic.

Present legislation is patently confused and inadequate in controlling the problem. Draft Directive 9148/84 to amend European Community noise standards for newly constructed motor cycles has been considered in some detail by a House of Lords Select Committee. Evidence to that Committee from a number of sources suggested that amendments to the manufacturers' requirements amounted to efforts in the wrong direction and that what is required is enforceable regulations to control noise from motor cycles in use. This should deal with what is probably the major problem of motor cycle noise, that is the deliberate tampering with exhaust systems for the specific purpose of making the machine more "sporty" sounding but at the same time more noisy.

In addition a view held by many, including the

National Society for Clean Air, is that a simplified but accurate stationary noise test procedure should be developed so that "noise traps" could be introduced.

REFERENCES

1. Manchester Area Council for Clean Air & Noise Control - Report "Motor Cycle Noise" 1986.
2. The Motor Vehicle (Construction & Use) Regulations 1978 and Amendments.
3. Method for the measurement of noise emitted by motor vehicles BS 3425.
4. Specification for sound level meters BS 3539 as amended 1968.
5. Council Directive 78/1015/EEC of 23rd November 1978 on the approximation of the laws of the member states on the permissible sound level and exhaust system of motor-cycles. Official Journal of the European Communities, No.L349/21. 13th December, 1978.
6. Draft Council Directive 9148/84, amending Directive 78/1015/EEC (COM (84) 438 final). Official Journal of the European Communities, No. C263/5. 2nd October, 1984.
7. Specification for replacement motor-cycle and moped exhaust systems. BSAU 193: 1983. British Standards Institute.

TABLE 1
FINDINGS OF GUILT FOR NOISE OFFENCES AT MAGISTRATES' COURTS, 1983

	Motor Cycle	Other Vehicle	Total	Motor Cycle %
Noise caused by faulty silencer.	2,527	9,910	12,437	20.3
Use of vehicle or trailer which causes excessive noise	168	338	506	33.2
Excessive noise through lack of reasonable care by driver.	97	78	175	55.4
Exceeding the maximum permitted sound level.	42	384	426	9.9
TOTAL	2,865	11,018	13,883	20.6

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ACTIVE NOISE CONTROL

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Active noise control techniques have a major role to play in reducing noise pollution. Although the technology has been researched and reported more widely over the last ten years, it is a concept that has been known for over 50 years. A patent was taken out in 1934 using a device which mixed acoustic waves causing destructive interference and thus weakening a sound field.

Before elaborating on the techniques, it is important to understand what sound is and how we, as humans, perceive it. Sound can be regarded as the disturbance of the air. Sound waves consist of a series of rapid increases and decreases in the pressure of the air following each other in succession - rather like the ripples produced by dropping a stone into a pond. When these pressure variations strike the ear-drum we hear them as sound - noise is merely unwanted sound. The ear is sensitive to changes in air pressure that occur at a rate of between 30 and 20,000 times a second (Hertz). In subjective terms the low frequency sounds are heard as a rumble and the high frequencies as a screech.

Active noise control is the science of cancelling one noise with another. In simple terms the concept can be explained in the following way. If we generate another sequence of air pressure changes at the ear-drum where decreases and increases coincide with the unwanted sound increases and decreases, then if the two sounds are exactly matched they will cancel out and we are left with no pressure changes at all, the result being silence! This then is the concept of active noise control. The art is in finding a way to generate electronically the exact opposite of the noise changes and use it to produce the exact

"anti-sound" via suitable loudspeakers or other devices. The illustration shown in Figure 1 should help to visualise the principle of active noise cancellation. The top trace is the noise level to be cancelled and is shown as amplitude changes in relative level against time. It is seen that it constantly changes. If it remained constant we would not hear it. The middle trace shows the cancelling waveform. To begin with, there is no cancellation. Then a waveform of equal amplitude but opposite phase is generated; the inverse of the noise waveform. The bottom trace shows the result of the two waves - the original noise and the cancelling noise and it is seen that the amplitude has diminished. The resultant wave is known as the residue.

The amplitude shape or characteristic of the noise depends on the type of source; for example, fans and gas turbines generate random noise whereas reciprocating engines and compressors and mains transformers have periodic or repetitive noise signatures. Active control has been applied to both types of noise source but each requires a subtle difference in the cancelling technique adopted.

Chronologically it should be mentioned that it was on large electrical power transformers that active control techniques were investigated in the 1950s and 60s; these are repetitive noise sources. Quite often, limited available space dictates that transformers have to be sited close to dwellings and the distinctive humming sound can be a noise nuisance. Because the noise generated is related to the mains frequency, it was relatively easy to generate the required cancelling signal to feed loudspeakers placed adjacent to the transformer. Cancellation was achieved in certain areas. Unfortunately, because of the

spatial distribution of the sound field, the cancelling wave combined with the original wave in other places to reinforce and thus intensify the noise. As a result of this, active control was abandoned. The control of transformer noise has now become a classic problem and is still currently being investigated.

It was not until the last decade and the advent of relatively cheap, powerful computers that substantial advances were made primarily in the UK on the implementation and practical use of active techniques. Early researchers into noise cancellation confined themselves almost exclusively to laboratory models of ventilation ducts, the obsession with which being partly explained by the one-dimensional propagation of the low frequency noise, and the consequent ease with which the cancelling noise mixes with the source noise when injected into the duct.

Figure 2 shows a duct within which noise is cancelled by injecting an anti-phase version from a loudspeaker either within, or at the outlet of, the duct. Since the loudspeaker has an inherent delay and the computation of the signal takes a finite time, prior information of the fan noise is needed, and is conveniently obtained by a microphone placed upstream.

The duct system can be used to highlight the salient features required for a cancellation system. These are a cancelling source, a microphone(s) and a controller. All noise cancellation systems require a cancelling source and this usually takes the form of a single loudspeaker or an array of loudspeakers, depending on the requirement. The cancelling source must be capable of generating sufficient acoustical intensity to cancel the noise. If it is not loud enough, poor cancellation, or worse, no cancellation will result. There is a

clear difference here as passive devices, such as silencers, will always provide some attenuation regardless of the absolute noise level. One advantage of active systems over their passive counterparts is that a high degree of cancellation is possible as the unwanted noise is carefully matched in its amplitude by the cancelling waveform.

At least one microphone is required for the cancelling system, but how it is used depends on the characteristics of noise to be cancelled. For random noise in ducts the microphone is used to sample the sound wave travelling down the duct, gathering information about the noise. Early cancellation systems in a duct used only one microphone. However, more recent systems are now adaptive, and require a second microphone to measure the residual noise. An adaptive system is one which automatically adjusts the controller characteristic to any changes in the working environment.

The controller is the clever part that takes the signal from the microphone and generates the correct electrical signal which, when applied to the loudspeaker, causes the loudspeaker output to cancel the noise down the duct. Many of today's controllers use microprocessors. Research has advanced to the stage where systems for cancelling noise in ducts are just about ready for commercial application.

One of the earlier systems to cancel random noise was used at the outlet of a large gas turbine which drives a compressor. Here an array of loudspeakers was mounted around the edge of the turbine exhaust stack. A mini computer controller was used to generate the cancelling signal which was then amplified and

fed to the loudspeakers. The system gave good broadband cancellation over the lower frequency range 20-55 Hertz. To achieve the same reduction with passive treatment would have involved the use of a large bulky silencer, structurally supported, capable of withstanding the high gas temperatures.

Diesel engines used on industrial sites and for transportation have for a long time been acknowledged as sources of low frequency noise pollution. This is an area where active noise control can play a major part in reducing noise levels.

In 1976 it was realised by the Wolfson Centre at the University of Essex that this major class of noise, engine exhausts, consists almost entirely of sounds exactly related to the rotation or firing rate of the engine concerned. The industrial research group devised a microprocessor controller to generate an equal but opposite sequence of sounds, using a tachometer-type device on the engine to lock these to the engine rate. No microphone was needed to determine prior knowledge of the noise to be cancelled. Being an adaptive system the microprocessor uses a microphone to test the success of the cancellation, and progressively refines the cancelling sound until the noise at the microphone is reduced to as near zero as possible. A schematic of the system is shown in Figure 3.

Early prototype industrial cancellation systems were installed on stationary engines - for example, standby generator sets and test engines. These systems proved most effective and reliable. Typically, the dominant low frequency engine related noise could be cancelled by as much as 20 dB. This is a marked reduction. Also, because the active

system does not impede the engine gas flow there is no backpressure, inherent with conventional silencers, to affect adversely the engine performance. Furthermore, the active system is potentially smaller and lighter and since the exhaust gases do not pass through the active silencer, their corrosive effect is eliminated. A passive silencer is still necessary to remove the middle and high frequency exhaust noise, but as these frequencies are easily attenuated, its physical size is quite small.

Another example of the practical application of active noise control is the cancellation of noise from a ship's engine funnel. The Wolfson Group successfully completed a project on a 750 ton ship, cancelling the noise from the exhaust. The ship is shown in Figure 4.

In 1985 in collaboration with the Transport and Road Research Laboratory a project to evaluate the use of active control on a heavy goods vehicle was completed. TRRL had previously developed their Foden quiet heavy vehicle, shown in Figure 5, which had extensive passive noise control treatment to reduce the external noise and included a specially designed silencer system. An active system to replace this silencer was designed and installed and in addition to being portable the system had to provide cancellation during rapid changes in engine speed. Typically the time taken for the engine speed to change from half to full speed is about one second. For the system installed on the vehicle, the cancellation performance is shown in Figure 6. This was the first ever installation on a heavy vehicle and clearly demonstrated that active control techniques could cancel low frequency exhaust noise.

Only examples of the use of active noise

control for reducing external noise have been mentioned here. The range of applications of noise control techniques currently being developed is wide, ranging from ear defenders to reduce high intensity low frequency noise at the ear to cancelling noise inside enclosed spaces, for example, aircraft cabins.

The practical application of active noise control techniques has demonstrated that low frequency noise can be reduced. Further technical development, however, is required in certain areas such as the development of more compact and robust cancelling sources. It is a technology that can make a contribution in reducing low frequency noise pollution and thereby help to improve the quality of our environment.

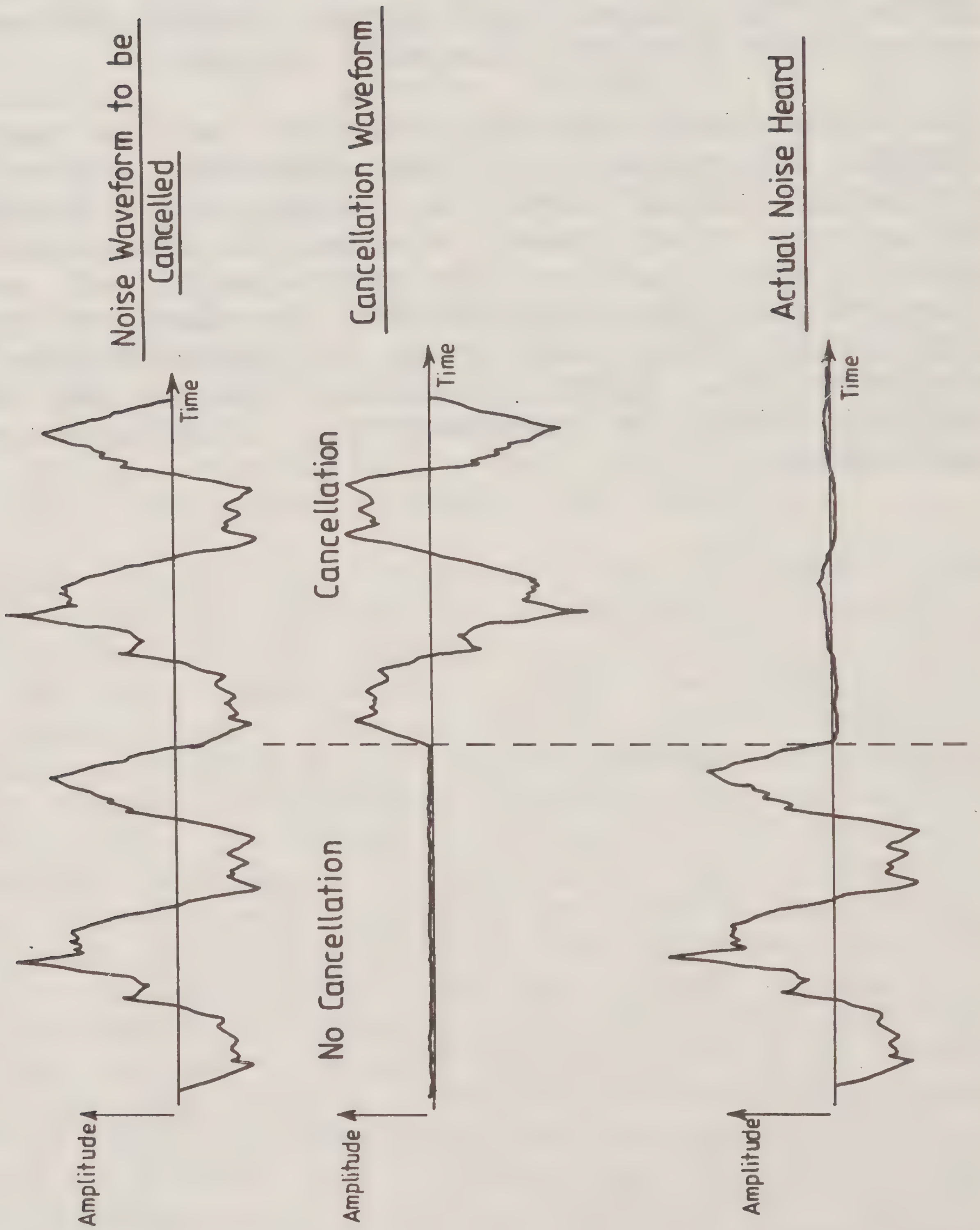

FIGURE 1: PRINCIPLE OF ACTIVE NOISE CANCELLATION

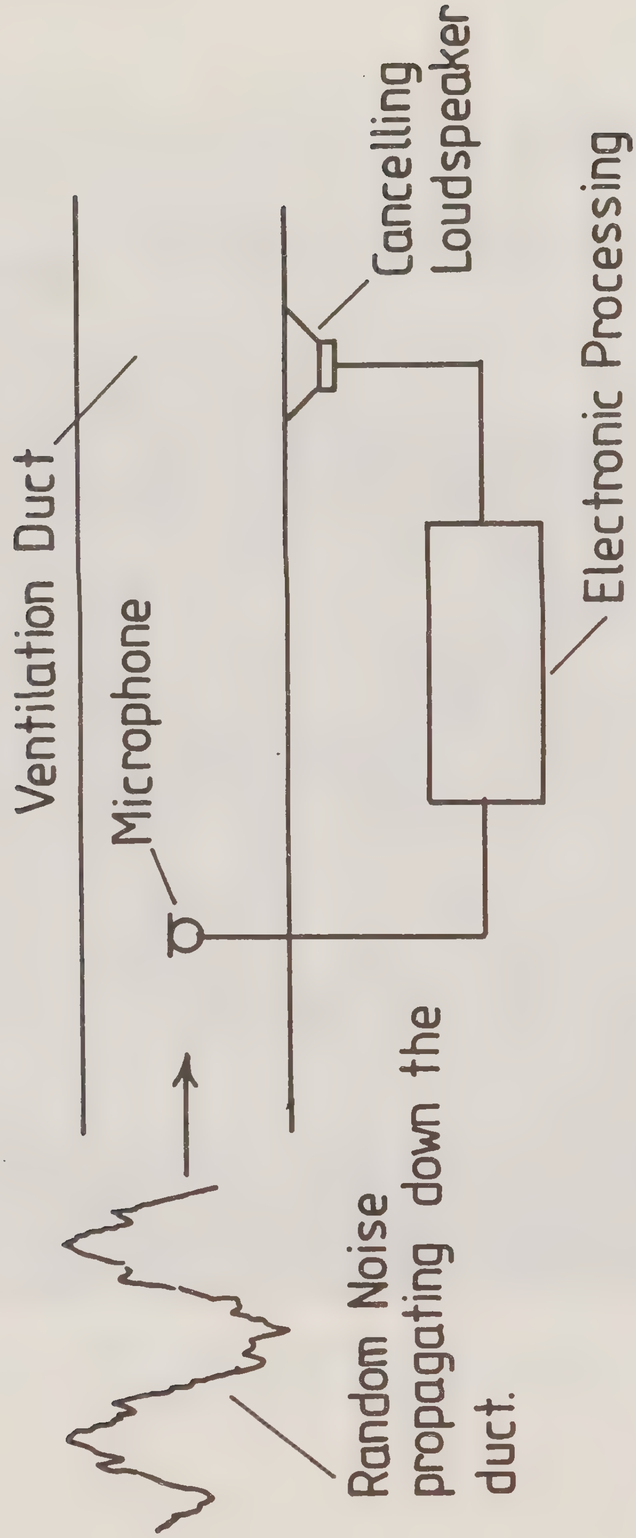

FIGURE 2: VENTILATION DUCT CANCELLATION SYSTEM

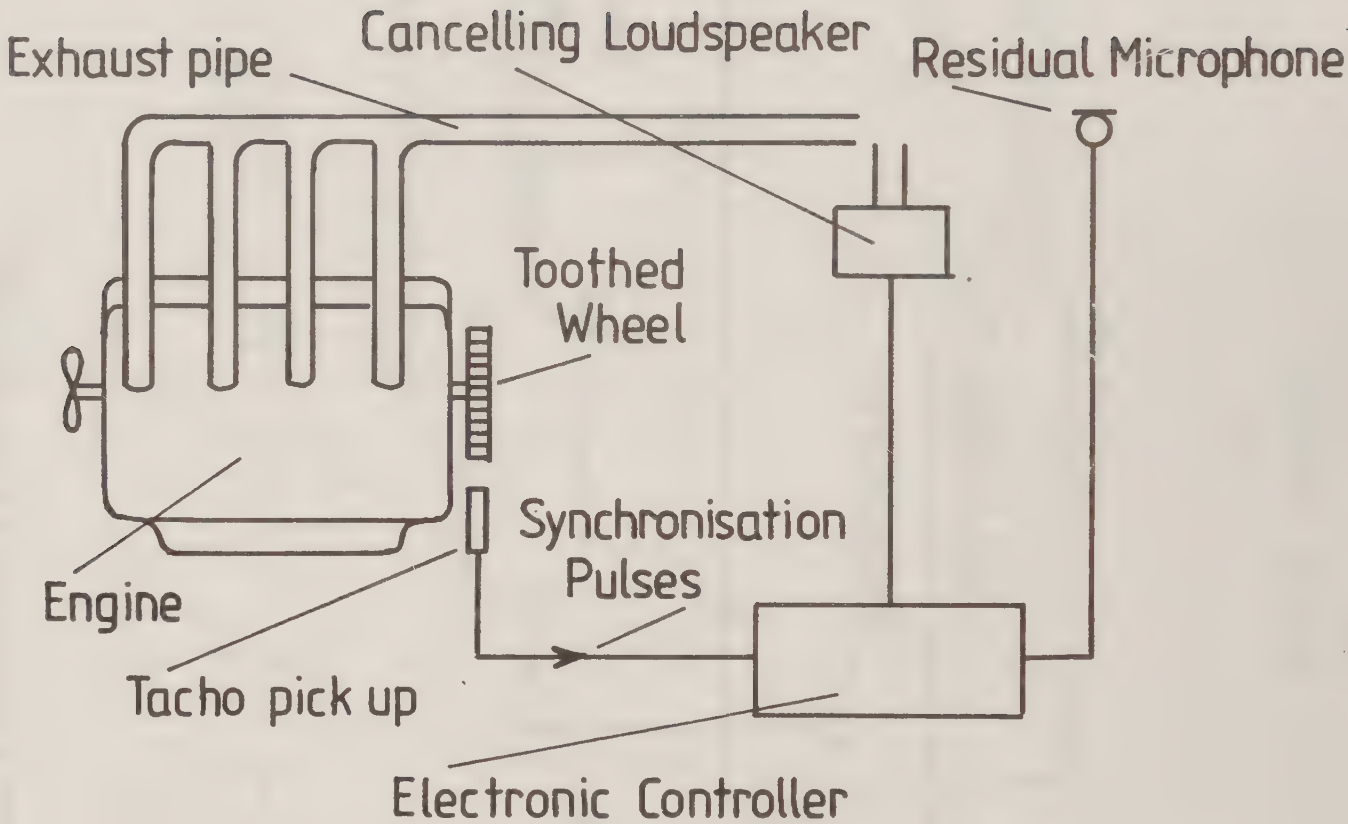

FIGURE 3: SCHEMATIC OF A SYNCHRONUS CANCELLATION SYSTEM FOR ENGINE EXHAUST NOISE

FIGURE 4: ACTIVE NOISE CANCELLATION
OF SHIP'S FUNNEL

FIGURE 5: ACTIVE CONTROL OF COMMERCIAL VEHICLE EXHAUST NOISE

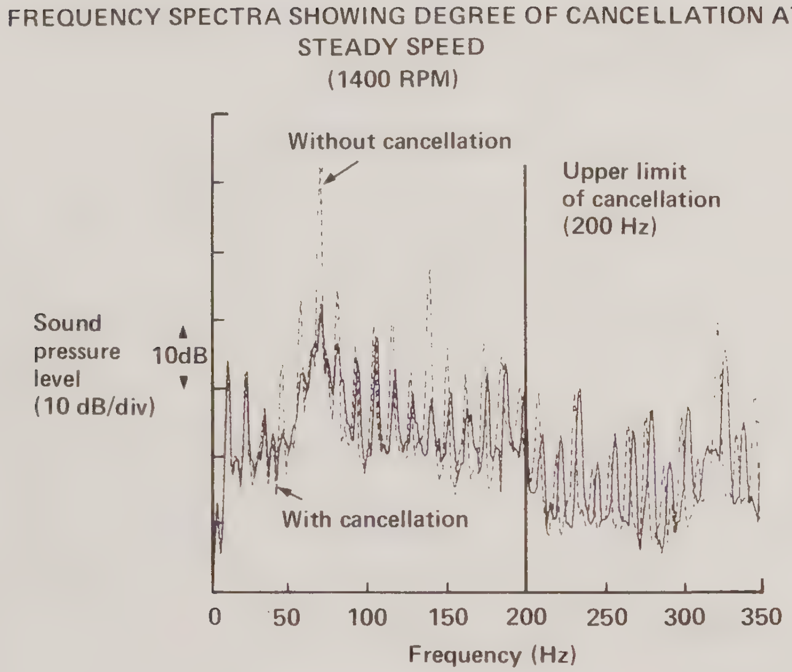

FIGURE 6: CANCELLATION PERFORMANCE ON THE QUIET HEAVY VEHICLE

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GLOBAL EFFECTS OF TRACE GAS CHANGES

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INTRODUCTION

A lot of attention has been paid at NSCA Conferences over the last few years, and with good reason, to the effects of pollutants such as SO_2 and NO_x, present in the atmosphere in concentrations of parts per hundred million or more. But there are other gases, some of which are found with concentrations several orders of magnitude lower, which may ultimately, directly or indirectly, exert an influence on the environment as great as that of the "traditional" pollutants. Many of these so-called "trace" gases are increasing in concentration, largely due to man's activities, and the potential effects of these increases must be understood.

The gases to which we refer are specifically methane (CH_4); nitrous oxide (N_2O); chlorofluorocarbons (CFCs) and carbon dioxide (CO_2). The presence of these gases has two consequences which, whilst linked, can be described separately. Firstly they are all active in the chemistry of the atmosphere; either the lower atmosphere (troposphere), the upper atmosphere (stratosphere), or both. One specific effect of this chemical activity is to influence the amount of atmospheric ozone. Secondly, they are all important gases radiatively; they absorb and radiate in the infra-red part of the spectrum whilst being relatively transparent in the visible. This property allows them to influence the heat balance of the globe and hence, potentially, the global climate.

TRENDS IN TRACE GAS ABUNDANCES

Careful monitoring of these trace gases over the past decade or two, coupled in some cases

with deductions made from indirect evidence going back further, indicate that the concentrations of these trace gases are increasing in each case.

CARBON DIOXIDE has been measured at several locations for many years; in particular at Mauna Loa, Hawaii, since 1955. Although its concentration shows a large annual cycle, there is also a very clear upward trend in annual averages; at present its concentration is 345 ppm and rising at about 1 to 1.5 ppm per year. The major cause of this increase is almost entirely due to the burning of fossil fuels in the developed world, with the contribution from deforestation presently thought to be only a minor one.

The major sink of CO2 is to the oceans, although they are only able to take up about half of the increased emissions - hence the rise in airborne concentrations.

METHANE concentrations have increased at a rate of about 1% per year since reliable measurements started in 1978; data from solar absorption show that this trend has probably existed since the early 1950s, and ice-core data indicate levels have been increasing for several hundred years. These increases are probably due principally to greater emissions, from larger areas of rice paddies and larger numbers of ruminant cattle and insects. The main sink of methane is by reaction with the hydroxyl (OH) radical, and an alternative reason for methane increases may be decreases in the loss rate because of lower levels of OH. The other main sink for OH is carbon monoxide (CO), and increasing emissions of CO may be "mopping up" OH before it can deplete methane.

NITROUS OXIDE has been observed to be

increasing in concentration at a rate of about 0.25% per year. Although there are substantial natural sources of N_2O, the increase is probably largely due to man-made sources - combustion and the use of nitrogenous fertilisers.

CHLOROFLUOROCARBONS are almost exclusively industrial in origin; they are used as refrigerant gases, as propellants for aerosol cans, and as agents for blowing expanded polystyrene. Production of CFCs rose at several % per year until the mid 1970s, when a combination of environmental concern and regulatory controls led to a sharp fall in production which continued until about 1982; output is now rising again. CFCs have no sink in the troposphere; they diffuse up to the stratosphere and are broken down by sunlight to give active chlorine. For this reason their lifetime in the atmosphere is about 100 years; many of the CFCs emitted today will still be around in a century. Because of this long lifetime, concentrations of CFCs have not yet reached equilibrium with emissions, and CFC levels are rising at about 6% per year.

THE EFFECTS OF TRACE GAS INCREASES ON ATMOSPHERIC OZONE

Ozone is being produced in the stratosphere and in the troposphere, but by different sets of chemical reactions, both of which rely on the action of sunlight. In the stratosphere ozone is destroyed by a series of catalytic reactions - those of interest to us involve nitrogen and chlorine compounds. The balance between ozone generation and ozone destruction at different altitudes results in a peak of ozone concentration in the stratosphere at a height of about 20 - 25 km.

The gases influencing the production and loss of ozone (and thus its atmospheric concentration) are just those trace gases whose changing behaviour has been described above. Computer based models, which represent the chemical and physical processes which determine the ozone concentrations, are used to predict the effect on ozone of hypothetical increases in trace gases. These models show that any increase in chlorine in the atmosphere (due to continuing use of CFCs) will act to deplete ozone in the stratosphere because of the greater catalytic destruction. A similar effect in the stratosphere will result from increasing nitrous oxide emissions, again due to more ozone destruction - in this case catalysed by nitrogen. Neither chlorine nor N2O has any significant effect on tropospheric ozone.

On the other hand, increasing CO2 levels will lead to greater abundance of stratospheric ozone; not because CO2 takes part in any chemical reaction but because it will cool the stratosphere and this in turn will slow down the rate of ozone-destroying chemical cycles. Increasing methane has a small positive effect on stratospheric ozone, with a realtively large positive effect on tropospheric ozone.

The quantity of most interest to us environmentally is the total amount of ozone in a column of the atmosphere - troposphere plus stratosphere. It is this "column ozone" which determines the amount of absorption of solar UV light. If too much UV light is allowed to penetrate to the earth's surface then this may have deleterious effects on the environment (aquatic ecosystems, materials) and on human health (the incidence of skin cancer), although there is still much work to be done to clarify the dose-response characteristics in each case.

Because the trace gases interact with each other, we cannot simply add up the change in column ozone due to each to get the net effect of simultaneous changes in all trace gases. Instead, more complex chemical models are employed to perform "multiple perturbation" calculations using "best guess" scenarios for the changing trace gas concentrations. Such models predict that (assuming a sustained 3% per year increase in CFC emissions) there will be only small decreases (< 1%) in column ozone over the next twenty years, because depletion in the stratosphere (due to CFCs) is almost balanced by increases in the troposphere (due to increased methane). Following this period, however, column ozone decrease becomes more rapid, leading to a 10% change by about the year 2050.

There are great uncertainties in these predictions. Firstly, our knowledge of the chemistry and physics which control ozone may be incomplete. Secondly, even the processes of which we are aware have to be simplified to enable computer simulations to be carried out, and these simplifications may lead to errors in the results. And thirdly, the model predictions can only be as good as the predictions of future trends in trace gas concentrations. In most cases our "best guess" scenarios assume the continuation of present day trends but, because this is based on limited understanding of the causes of these trends, we must treat this extrapolation with considerable caution.

Has any change in column ozone been detected so far? In general the answer is no; there is no statistical trend in the global average of the total column of ozone in the atmosphere, and this is not inconsistent with the calculations

of models which take into account the increases in all the trace gases so far. However there is an important exception.

Scientists at the British Antarctic Survey have been making measurements of column ozone over Halley Bay since the 1950s. A couple of years ago they noticed that ozone levels during austral spring had been decreasing since about the late 60s and are now some 40% less than when records started. This effect has since been confirmed by looking at satellite observations over the last 7 years, and these also show that, whilst the region around Halley Bay is the worst affected, some depletion has occurred at latitudes up to 45 degrees South. The phenomenon is largely restricted to springtime, when the stratosphere over Antarctica is once again irradiated with sunlight after the long antarctic winter.

Whilst many hypotheses for this "ozone hole" have been advanced, there is yet no acceptable explanation. We cannot tell whether the depletion will remain essentially confined to Antarctica due to the unusual springtime conditions or if it has implications for the global ozone layer. Furthermore, we do not know if the depletion is due to increased chlorine levels arising from continuing CFC emissions, or if it is a manifestation of some purely dynamical effect. A small scientific expedition is being mounted about now, in the current austral spring, followed by a much larger one in 1987, and the large number of observations made will allow many of the hypotheses to be tested.

THE GREENHOUSE EFFECT

The temperature of the earth's surface is determined by the balance between incoming

(shortwave) solar radiation absorbed by the earth, and outgoing (infrared) radiation emitted by the earth. A simple calculation shows that this balance is achieved when the surface temperature of the earth is about minus 20 degrees Celsius, whereas the measured global average surface temperature is about plus 15 degrees C. The reason for this is that the earth's atmosphere, whilst allowing in solar radiation virtually unattenuated, absorbs and re-radiates much of the terrestrial radiation, leading to a much higher equilibrium surface temperature. This is the "greenhouse effect", so called because glass in a greenhouse allows in sunlight but traps heat.

The constituents of the atmosphere which do this trapping - the "greenhouse gases" - are primarily water vapour and CO_2. Obviously any increase in their concentration will lead to more terrestrial radiation being trapped and higher equilibrium surface air temperatures - the global warming. Furthermore any additional greenhouse gases will also have the same effect. In fact, because the absorption due to CO_2 is already close to saturation, additional CO_2 molecules will have progressively less effect on the infrared transparency of the atmosphere; whereas molecules of any "new" greenhouse gas (such as CH_4, N_2O, CFCs, and including ozone) will absorb in different parts of the infrared spectrum where the atmosphere is still largely transparent (the "window" region) and will have a relatively greater effect than CO_2 on a molecule by molecule basis. Each molecule of CFC12, for instance, will have the same effect on global temperature as about 10,000 molecules of CO_2. (But of course the rate of increase in the number of CO_2 molecules is much greater than that of CFCs.)

how tentative these are.

Finally, it is worth asking if any temperature rise has yet occurred. Records of surface air temperatures, land and marine, kept over the last hundred years, have been carefully analysed to look for any trend which might suggest that a global warming has already begun. One such analysis shows a significant trend of about 0.5 degrees C per century; largely determined by a period of low temperatures in the late nineteenth century. Another analysis shows no significant trend, and work is in hand to resolve the difference in these analyses.

CONCLUSION

We have seen that a knowledge of the behaviour of a range of trace gases in the atmosphere, an appreciation of the reasons for this observed behaviour, and a study of the effects which they may have on the physics and chemistry of the atmosphere, is basic to a number of areas of environmental concern. We need to achieve a better understanding of the atmospheric chemistry of trace gases, so that if any actions need to be taken to avert possible environmental consequences, they can be taken on a logical and well-informed basis.

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OZONE PRODUCTION DOWNWIND OF LARGE CONURBATIONS

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53rd CONFERENCE PART TWO Report of Discussions

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Ozone Production Downwind of Large Conurbations

Editor: Jane Dunmore

KEYNOTE SPEECH

by
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INTRODUCTION

Mr Chairman, Mr President, Mr Mayor, ladies and gentlemen, my first duty is to convey my Ministers' apologies that pressures of Parliamentary and European Community Presidency business make it impossible for one of them to be here tonight to participate in this opening of your 53rd Conference. But speaking as one raised in this town, I am delighted that their enforced absence has given me the chance to come to Blackpool tonight and join in your proceedings. Your programme for the next three days makes it clear that you are in for a lively and informative discussion, touching on many of the central issues that will concern practitioners in the field of air pollution control over the next few years.

REVIEW OF AIR POLLUTION CONTROL LEGISLATION

Tomorrow morning you will be considering possible changes in the United Kingdom's air pollution control system, and Commissioner Clinton Davis will be giving you a European perspective. The Government has for some time been considering how the British control system should be developed. We hope to issue a consultation paper before Christmas.

That paper will address some of the important issues to be

discussed tomorrow morning by two of your speakers. I would like to mention three of them.

First, I would like to reassure you that we will continue to stand by the familiar UK principle of best practicable means, but we will be looking at the scope of its application. This system is not used (or always understood) by our continental neighbours in the Community but it does offer a number of special advantages. It offers control over a whole process. It is flexible and has regard to the state of technical knowledge, to financial implications and to local conditions and circumstances. And - I think we should not undervalue this point - it is familiar to industry and to the control authorities and has a proven record of success.

Secondly, we will need to look at the implications for our own system of control of the European Community "Framework" Directive on combating industrial air pollution. The Directive covers a somewhat wider range of processes than are currently "scheduled" by the Industrial Air Pollution Inspectorate, including some that are now controlled at the local level. Local control has many advantages. We have hitherto restricted the processes for which the IAPI is responsible to those that really require their specialist attention because of technical complexity or high pollution potential. Otherwise, we have regarded industrial air pollution as a matter appropriate for local control. We will clearly have to look at how prior control should be extended beyond the current scheduled processes and how the work of the IAPI and local agencies can reinforce one another most effectively.

My third topic is the question of "openness on environment matters". Many of you will remember the Royal Commission on Environmental Pollution's recommendation in their 10th Report that there should be unrestricted access to information which the pollution control authorities obtain through their statutory powers. In response to this proposal the Government set up a working party. Its report, "Public Access to Environmental Information", was published by HMSO in April as Pollution Paper No 23. That report lists a number of ways in which the public had already been given greater access to environmental information since the Royal Commission had published their report. But there are still

more things that can be done. The Report therefore recommended further changes in law and in administrative guidance to meet the Royal Commission's principal recommendations.

The Government accepted that broad thrust of the report and the process of detailed consultation has begun. Local authorities will of course have a part to play. The Local Government (Access to Information) Act 1985, which as you know came into force in April this year, can be expected to result in greater openness in the pollution control activities of local authorities, especially in relation to air pollution and waste disposal. Bu we hope that industry too will recognise the advantages, in terms of public confidence, of making information more readily available. As William Waldegrave said in the Federal Republic of Germany in September 1985, "Secrecy benefits nobody. It cannot be in industry's interests to hide information which does not need to be hidden. The public are bound to think the worst."

HMIP

I have already mentioned the Industrial Air Pollution Inspectorate. Recently the Government announced that a new unified Inspectorate will come into being on 1 April next year. Her Majesty's Inspectorate of Pollution will continue to carry out the functions of its constituent Inpsectorates - the Industrial Air Pollution Inspectorate, the Radiochemical Inspectorate, the Hazardous Waste Inspectorate and a new Water Inspectorate. But I believe it will soon become clear that the new body is greater than the sum of its parts. There is much to be done in developing a more coherent approach to the control of polluting emissions.

Many industrial processes may offer little choice as to the form their wastes take or the medium to which they must go. But there are occasions when a choice is available. In the past we have not been well organised to assess which process or which disposal route constitutes the best practicable environmental option. But I believe that we have now set the scene for public consideration of BPEO, and that the new Inspectorate will have a significant role to play in developing the concept and as a centre of expertise which

will be of considerable value to other control authorities.

ACID RAIN

I would like tonight to refer also to another recent Government announcement, made on the 17 September, that featured strongly in the lively seminar on acid rain that your Society organised in London on 19 September in partnership with the Institute for European Environmental Policy.

On 11 September my Secretary of State said that the Government had now authorised the CEGB to retrofit 3 major power stations, some 6,000 MW of generating capacity, with flue gas desulphurisation equipment. Subject to satisfactory design processes and final approvals, the programme will start at Drax B, and be phased over the period between 1988 and 1997. It is estimated to cost some 600 million. We have also announced that all future coal-fired electricity generating stations will be fitted with this - or equally acid free - technology. This will keep the trend in British sulphur emissions - which have already fallen more from their peak in the early 1970s than those of most European nations - in the right direction - downwards. It will keep us on course to achieve our stated aim of a 30% reduction in emissions from the 1980 levels by the end of the 1990s. It may even enable us to de better - but that depends on future energy scenarios, which remain uncertain.

VEHICLE EMISSIONS

As scientists have begun to probe the causes of the devastating die-back in the forests of Germany, Switzerland, Sweden, Austria and other countries, suspicion has become focussed on secondary air pollutants, especially ozone. And this in turn has brought increasing attention to the hydrocarbons and nitrogen oxides released by vehicles. The UK is one of the countries that led in the negotiation of the package of measures agreed by all except 2 members of the European Community. We hope that package will soon be accepted formally.

Meanwhile, we have taken steps to deal with another

notorious pollutant from motor cars - lead. From the beginning of this year, the lead content of leaded petrol - needed by most cars on our roads today - was reduced by two thirds. And we are also well on target to make unleaded petrol widely available throughout the United Kingdom. Since June it has been on sale at nearly 200 filling stations. The oil industry is clearly responding to the challenge and is taking an active part in the public information exercise that will be necessary if this new fuel is to be used properly. I am sure that the car manufacturing industry - which has already devoted much effort to the development of lean burn engines to reduce pollution - will play its part.

RESEARCH PROGRAMME

The Government believes that environmental protection policies must be based on sound scientific research. My Department is spending over 4 million a year in studies of air pollution and acid deposition. Our programme covers the whole pathway from emissions to targets. It takes into account chemical transformations in the atmosphere and transport and deposition mechanisms. We have greatly expanded our efforts in monitoring and compiling emission inventories for those pollutants that are known to make a major contribution to acidity in the environment - sulphur dioxide and nitrogen dioxide - or to be implicated in damage to trees and plants - ozone. I note that you will be hearing much more about these on Thursday afternoon. We now have in place networks for monitoring acid deposition in the UK and are setting up others to measure nitrogen oxides and ozone and rural levels of sulphur dioxide. These will provide us with a much better picture of air pollution and acid deposition in the UK.

We are continuing to give high priority to research on effects on crops, trees and vegetation - and particularly on the impact of acid deposition on freshwater quality and eco-systems. We are funding a number of studies of freshwater catchments, because we recognise the importance of the interaction between acid deposition, water and soil chemistry, and land management practices. Data from these studies are now being used to develop models, which can be applied to investigate the impact of different emission

control strategies and to assess the sensitivity of processes affecting acidification.

The Select Committee on the Environment, in their report on acid rain, criticised the Government for not supporting enough research on the effects of acid deposition on historic buildings. In response, work has been intensified, especially by the Department's Building Research Establishment. We are studying in particular the effects on Lincoln and Wells Cathedrals and Bolsover Castle. We have also included in the programme some engineering and economic assessments of control technologies.

Such research needs to be evaluated before we can move to new action. I would like in this connection to pay tribute to the independent expert groups we have established to examine key aspects of the acid deposition problem. Reports by the Acid Rain and Acid Water Review Groups have already been published and other Groups' reports are expected before the end of the year. I commend them all to you.

NOISE

On Thursday morning the Society will be considering noise. I would like to emphasise that the Government's concern to bring noise under control remains undiminished. I am sure that most people will recognise that in a country as densely populated as ours this is by no means an easy task. As the papers to be presented on Thursday show, we need to seek the reduction of noise at source, protection from excessive noise, and the encouragement of consideration for others. The proposed teaching pack, and other publicity produced by the Society, is important here.

How can Government help? First, by the implementation of the measures to combat environmental and neighbourhood noise, through Part III of the Control of Pollution Act 1974.

Second, through the preparation or approval of codes of practice on minimising noise from particular sources. Such codes do not create offences or have the force of law, but I believe they can help Local Authorities and Magistrates' Courts in exercising their powers under the Control of

Pollution Act. The British Standards Institution Code of Practice for Noise Control on Construction and Demolition Sites (BS 5228) has also been approved by the Secretary of State.

For many years, vehicles manufactured for use on the road have had to comply with regulations which lay down the maximum noise they are permitted to make. Motorcycles are no exception, and stricter noise limits have been applied to all those first used on or after 1 April 1983. The Commission of the European Committees has recently proposed limits to take effect in 1991. The Government does not think the Commission's proposals are nearly strict enough, especially in the way they apply to the smallest motorcycles, which form over half the market in the country. We are therefore pressing for more stringent limits. We hope that it will be possible to make progress on this at the forthcoming Environment Council. But we are not ignoring other problems, such as replacement exhaust systems. Enforcement is important too; over 2,800 motorcyclists were successfully prosecuted for noise offences in 1983, mostly for having defective silencers.

Finally, I know that the Society's Noise Committee has undertaken a number of studies, in particular on noise in converted flats, which is a subject of another of the papers to be presented on Thursday. I cannot of course promise that the Government will always share the Society's view, or follow its recommendations, but I can assure you that the work of the Noise Committee will be studied carefully and with interest. We wish it well.

DOE GRANT

It is an implication of the value we place on the work of the Society, that this year the Department has been able to help you in a practical way with a 3 year contribution from our Special Grants Programme. The Society is, I understand, planning a number of initiatives, including teaching packs on noise and air pollution, for use in schools. We welcome this and hope that these projects will be successful and widely used. Making a new generation conscious of the effects of noise and pollution could have a directly beneficial effect in

years to come. We recognise, too, the important role of the Society's other publications such as the Reference Book and the Members' Handbook.

EUROPEAN YEAR OF THE ENVIRONMENT

I have touched on a number of environmental issues that concern your Society. I believe that it is important to see environmental issues in the round. Next year there will be an important opportunity for us to get that message across.

Many of you will be aware that next March marks the start of European Year of the Environment. The main aim of the Year is to raise awareness of the environment in all walks of life so that better progress can be made in its conservation and improvement. We have appointed a national committee under the chairmanship of Sir Peter Harrop to organise Britain's contribution. The Committee will be focussing on the conservation of the Natural Environment, the Control of Pollution and Waste, and the improvement of the Urban Environment, including the treatment of eyesores and dereliction.

I hope that the Society will be able to play a part in EYE. We have asked Don Barnett, former Chairman of your South West Division and a speaker tomorrow morning, to sit on the Committee. I hope also that members of the Society, acting either as individuals or as representatives, will be able to stimulate interest in the Year throughout the country.

I also hope that many of you will be able to attend the International Pollution Abatement Fair which will be running alongside the Public Works and Municipal Services Exhibition next April at the NEC. That exhibition in many ways points to the key to our overall approach to the environment. Economic growth and environmental protection should be seen as mutually reinforcing goals.

It is only through economic success that we are able to afford the environmental standards we all desire. And, as I hope the Pollution Abatement Fair will show, protecting the environment itself, if done well, provides economic opportunities. That in itself is an important message. The

experience of all those involved in pollution control - and so particularly this Society with its long and honourable tradition of galvanising public awareness of the dangers of air pollution - will have a key role to play.

I wish your Conference every success, and am grateful for the opportunity of speaking to you.

DISCUSSION - SESSION 2
"POLLUTION CONTROL"

Speakers: Mr. S. Clinton Davis, Dr. A.K. Barbour, Mr. D.J. Barnett

MR. A.A. ARCHER (Past President of the Institution of Environmental Health Officers and a former member of the Royal Commission on Environmental Pollution), opening the discussion, said that Stanley Clinton Davis' presentation had emphasised his own opinion that the time was right for a reappraisal of the EEC's environmental action programmes. Anxiety over such issues as acid rain, the greenhouse effect, the ozone layer and, most recently, nuclear radiation had made it clear that air pollution had long since ceased to be a purely national issue.

Mr. Archer commended Dr. Barbour's presentation as a detailed analysis of industrial air pollution legislation, and said overall the views expressed were valuable in combining the respective interests of industry, central goverment and local authorities. There was an inconsistency in the approach to air pollution control both within the European Community and nationally between the Industrial Air Pollution Inspectorate and local authorities, as the papers by Dr. Barbour and Mr. Barnett had shown. Mr. Archer questioned whether the excellent principle of BPM had always been exercised in practice. Was the best available technology always used to reduce emissions to a minimum? Dr. Barbour had also put the Polluter Pays Principle into proper perspective. In practice, of course, it was not the polluter who ultimately paid but the consumer. This was realistic and acceptable providing that the consumer was satisfied that the pollution control was effective. Dr. Barbour had made the point that scientific proof was rarely obtainable in the environmental world. Despite this, Mr. Archer thought it important to avoid raising the profile of certain issues through anxiety rather than through scientific fact as some pressure groups were guilty of doing.

Don Barnett's paper had highlighted the difficulties facing Environmental Health Officers as a result of ineffective prior approval powers. Non-combustion processes where emissions were at a low level were a particular source of nuisance. Don Barnett's suggestion of a co-ordinating air pollution control body was an excellent one, since uniformity of approach was essential. Mr. Archer particularly wanted to see the development of the concept of the best practicable environmental option, since air pollution could not be considered in isolation from pollution of land and water. Mr. Archer also advocated the inclusion in such a co-ordinating body of several Environmental Health Officers, who would liaise with local authorities. Mr. Archer complimented the three speakers on providing an excellent curtain raiser to the conference.

MR. S. ALKER (Kane-May Limited) had a question on the measurement of emissions in car exhausts and large boilers and who was empowered to perform such measurements, if anyone.

He had recently visited two industrial fairs abroad, where he had been impressed by the extensive range of monitoring equipment produced. This was evidence, perhaps, of the seriousness with which the Europeans, in particular the Germans, took the air pollution legislation in force. He doubted whether the same faith in the implementation of legislation existed in this country and commented on the absence of industrial representatives, apart from those exhibiting, at the conference, which was perhaps because they felt that they would never be compelled to control or monitor boiler emissions or monitor car emissions. British manufacturers of monitoring and control equipment dared not speculate on new types of equipment as our European partners could because they were unable to predict when industry would be compelled to use such instruments. The vast range of very sophisticated and specific control and monitoring equipment on display at the fairs he had visited was produced because the manufacturers knew that it would have to be used. In Germany TUV had inspectors constantly checking on boilers and also on car emissions in much the same way as we in Britain have the MOT test. There were

no equivalents to this in the United Kingdom and Mr. Alker suggested that this was because of our lack of faith in the implementation of legislation. His question was how could faith be restored.

MR. A.J. CLARKE (Central Electricity Generating Board) considered that the Commissioner had been unfair in his description of the CEGB's environmental policy and regretted the fact that he had not had time to stay for the discussion. The scientific evidence awaited by the CEGB before taking action had only become available in the spring. It had then been an initiative by the CEGB that resulted in the proposal to retrofit power stations with flue gas desulphurisation to such an extent. In addition all new fossil fuel generating plant would be equipped with FGD and other control equipment. With two or more new power stations to be built within the next ten years, altogether at least 10,000 megawatts of generating capacity would be equipped with FGD. These facts had not been made clear in the Commissioner's presentation. Mr. Clarke said that the measure would cost £1 billion in total and he could not think of another single environmental measure of such magnitude. It was equivalent to 10% of the world's present FGD capacity, although the Board did not burn anything like 10% of the world's fuel. Mr. Clark's rhetorical question to the Commissioner was whether he might not have been a little unfair to the CEGB concerning the part they had played.

CLLR. JOHN EVANS (Rhymney Valley District Council) believed that it was the aim of all present to achieve a better environment. Despite that, Cllr. Evans felt bound to question Dr. Barbour's claim that transfer of pollution was not yet a generally serious issue. What was needed was an acceptance of the spirit underlying air pollution legislation so that industry would recognise that there were problems and work with others to solve them instead of denying their existence. Expectations of environmental standards were higher in the first world than in the third and Cllr Evans suggested that the role of the multi-nationals was crucial in determining this. Profits could no longer be the overriding consideration for industry. Time

was not on our side and a dead world would not buy the products of any industry.

CLLR. MRS. LIZ SOLKHON (Brighton Borough Council) had a question concerning education, particularly of magistrates. Education was essential for such lay people who had the ultimate responsibility for enforcing air pollution legislation. All too often magistrates, faced with the prospect of closing down a plant which provided employment in the area, misinterpreted the concept of best practicable means when used as a defence by the plant operator. If wider powers were given to local authorities, as Cllr. Mrs. Solkhon hoped they would be, it was essential to ensure that magistrates had the necessary expertise to see that the legislation was implemented.

DR. R.A. BARNES (Esso Petroleum) had a question for Mr. Wainwright. Stanley Clinton Davis had mentioned that the intention was to apply the draft large combustion plant directive to units with outputs over 50 megawatts. Dr. Barnes asked whether this meant 50 megawatts output and not 50 megawatts input and how the distinction was to be made clear to officials.

MR. STEPHEN CARDEN (Barnsley Borough Council) asked Mr. Wainwright whether he agreed that research into new technologies for the clean use of coal was essential, not only for the environment, but also for the coal industry. If so, what support could the Commission lend to such research and what direction should it take.

CLLR. E. BRISTOW (Avon County Council) referred to Dr. Barbour's comments about the role of pressure groups and public opinion. Speaking as one who lived in the shadow of the RTZ complex at Avonmouth, he assured Dr. Barbour that it was the local community which galvanised him and his colleagues into action, not the media. The area had a complex mixture of heavy chemical and metal manufacturing, which had been nicknamed "The Avonmouth Cocktail". The area had been subject to many serious leaks over the years.

Mr. Bristow asked Dr. Barbour whether he would welcome Environmental Health Officers like Don Barnett being given greater power to investigate some of these problems.

THE CHAIRMAN then invited the PANEL to answer the questions.

MR. R. WAINWRIGHT, speaking on behalf of Mr. Clinton Davis, took up Stephen Carden's question about research into new technologies for the clean use of coal. The Commission was very interested in such projects and had a programme called the Ace Programme, which could lend some financial support, albeit limited. A proposal was to be put to the Council of Ministers to extend this programme and thus enable it to provide greater finance. In the European Year of the Environment, the Commission intended to raise awareness of environmental pollution and to market control technologies, particularly in the Third World. Mr. Wainwright felt it more appropriate to deal with Dr. Barnes'technical question regarding the Large Combustion Plant Directive separately in a written answer.

Mr. Wainwright then turned to Mr. Clarke's complaint that the CEGB had not been treated fairly by Stanley Clinton Davis. He thought that there was a general feeling in Britain amongst industrialists that they were not treated fairly in Europe. Indeed, Britain's image in Europe was not good: Britain had earned itself the name "Dirty Old Man of Europe". This was partly owing to its foot dragging over such measures as the large combustion plant proposal, which could cut emissions by 60% by 1995. Britain, of course, was not alone in its objections, but, having also failed to sign the Helsinki Protocol to the Geneva Convention, was seen as lagging behind its neighbours. In the field of road vehicle emissions, Britain had again ranged itself with those countries which sought less stringent standards and which had forced a compromise. There were, however, signs of a changing attitude on the part of the British Government and a recognition of the importance of remedying our poor environmental image in the context of exports to other countries and good relations with the Continent. The Commission welcomed this increased interest and awareness, as exemplified by the decision to retrofit certain power

stations with FGD (although in the Commission's view this did not go far enough) and the greater concern over emissions of NOX.

DR. BARBOUR, referring to Cllr. Evans' point about the seriousness of acid rain, felt that there had been some misunderstanding. He had been using the term "pollution transfer" in the sense of the Fifth Report of the Royal Commission on Environmental Pollution, ie that there was little point in solving one pollution problem, only for it to result in another. He had not intended the term to refer to trans-boundary air pollution, such as acid rain. Mention had been made of the role of multi-nationals in the Third World. While not wishing to become involved in a political discussion, Dr. Barbour pointed out that the problem lay not with new plant, which always used the best technology available, but with the cost of upgrading old plant. It was no longer possible, particularly in the metals industry, to pursue the line of profit at all costs.

DISCUSSION - SESSION 3
"COMBINED HEAT AND POWER"

Speakers: Mr. G. Atkins, Mr. R.W. Grey

MR. M.S. ANKERS (Manchester City Council), opening the discussion, suggested that the afternoon's session might have given the impression that Combined Heat and Power (CHP) was a universal panacea. Mr. Atkins had said that the technology, the skill and the finance were available, only the national will was missing. The first stage of the Atkins Report, produced in 1982, had confirmed the viability of CHP on a city-wide basis. Manchester, one of the cities surveyed in the study, had had Combined Heat and Power and District Heating for some time, though not in combination. The sole remaining power station within the city's boundaries was privately owned by a chemical company and steam was used for driving the generating sets and for process and building heating. The balance of heat to electricity had shifted over the years and led to the need to vent high pressure steam to atmosphere, which in turn created a noise problem. One of the reasons for this CHP system had been the high cost of using electricity from the grid, which meant that it was more economical for that Company to lose steam and generate their own electricity than to import energy from the grid. Fortunately the CEGB's policy had changed and these problems no longer existed.

Mr. Ankers was perplexed by the apparent lack of enthusiasm and slowness in the adoption of CHP. The concept and practice of CHP was not new, nor was the need for a national energy policy. Why then the delay? He suggested that the financial aspect might be the stumbling block. His authority's experience with heat metering had confirmed the theory that when finances were tight the domestic consumer cut back on central heating. Proper metering systems would give the domestic user complete control over the amount of heat used and paid for. He felt that this was one of the

things that should be examined along with the CHP policy. There were sound financial and environmental benefits associated with CHP but, if it were looked on as a cure-all, progress in CHP would be hampered.

Mr. Ankers summarised the advantages of CHP as: increased energy efficiency, thus stabilising heating costs; an acceptable method of domestic or even industrial waste disposal, thus reducing tipping space pressures; and, finally, a means of reducing overall the grosser atmospheric pollutants such as sulphur dioxide and dust (though dioxins, acid gases and heavy metals might pose a problem). An appropriate mix of CHP, CHP and District Heating, and CHP Waste Disposal Systems could bring great benefits. The amount of investment needed was not significant when compared with the six hundred million pounds which was initially to be put into flue gas desulphurisation.

Mr. Ankers commended both speakers for their highly competent, if technical, presentations and encouraged delegates to take their message home to their local authorities.

MR. R.G. WEBB (Cheltenham Borough Council) asked for further details on the teething problems associated with small CHP plant and for an elaboration on the noise problems, including details of noise output and whether or not acoustic enclosures were effective.

MR. R.W. GREY, responding, said that noise outputs from the small units with acoustic enclosures were typically 60-70 dB(A) at 1 metre. Obviously noise levels depended on the quality of the acoustic enclosure used and noise could be further reduced in many cases, although he thought that the figures he had quoted compared well with noise output from other plant usually found in a boiler house. Noise was not generally a problem with micro-CHP units. If the site was particularly sensitive, i.e. a residential area, the unit manufacturers would be able to discuss further noise reduction measures.

As to teething problems, Mr. Grey admitted that there had been a variety of these, although none had proved insoluble. They had included, for example, problems associated with

transferring enough heat from the CHP unit to the building's heating and hot water circuits to achieve the maximum number of CHP operating hours with the minimum amount of cycling on and off. The application of any new technology involved problems and the suppliers were learning from the early difficulties and rectifying these by adapting installation practice, system controls and unit components for future sales. He expressed his willingness to discuss any particular problem afterwards with the questioner. As he had made clear in his presentation, ETSU noted all problems in their monitoring reports and by no means sought to keep such difficulties secret.

MR. G. W. BARRETT (Central Electricity Generating Board) hoped to provoke a discussion between the two speakers. Mr. Atkins had talked more about the large-scale CHP applications although he had not dwelt on the costs and difficulties of providing a heat load for the large-scale systems in many of the figures that he had presented. The costs could be enormous, although so too could the benefits. Mr. Grey had talked about smaller scale applications, which were developing rapidly and likely to do so even more in the future, especially when combined with other developments such as heat pumps in the domestic sector. Mr. Barrett wondered whether the development of these small-scale schemes would effectively be the death knell of the large-scale schemes, because of the infrastructure and capital expenditure needed to develop the larger applications. He believed that such "warfare" had already begun in Scandinavia. There, the costs of the infrastructure needed for the large-scale schemes had tended to mitigate against their further development.

MR. G. ATKINS, responding, agreed that in his presentation he had not dwelt long on the costs of developing heat loads but, as he had pointed out at the beginning of the talk, it was difficult to know at what level to address such a mixed audience. If he was addressing an engineering seminar, he would naturally have discussed costs in greater detail. However, he could say briefly that the range of costs for development of core schemes was anything between £100-150 million, to £600-750 million over a 20 or 25 year period.

Mr. Atkins saw no real potential for internecine strife between the Combined Heat & Power Association and the micro CHP suppliers. Since his period as chairman of the Association, he had actively helped to develop the three arms of the CHPA interest along the local authorities route via the liaison group and CHP City Studies Group and,in parallel, with an industrial group comprised of companies such as Balfour Beattie, Foster Wheeler, and NEI Parsons.

He considered that it was important not to confuse local authority representatives with too many highly technical matters, although if they were interested in detailed technical and economic assessments of CHP, the Association would be delighted to provide the details.

He had been interested in the comments about Scandinavia, having spent some considerable time over there himself. He was aware of the development there of micro CHP schemes, but his feed-back information was that government policies were still directed towards large-scale CHP/DH developments. Several such schemes in large cities on the Continent were actively expanding, e.g. the Copenhagen scheme which was currently undergoing considerable expansion. He did not see any difficulty in living alongside the micro CHP developments and in fact had become involved in such applications in his practice, particularly for sheltered dwelling complexes and hotels. It was essentially horses for courses.

MR. GREY said his presentation had stated that the small-scale CHP applications should ideally be sized only to meet base heat and electrical load. Normally some kind of supplementary heating would be needed in addition to the heat suppled by the micro CHP unit and supplementary electrical power would be purchased from the grid. Indeed, the large and micro applications could be complementary, and any potential for conflict was as yet a long way off. The issue would not arise for many years, if at all.

MR. ATKINS added a very personal comment. He said that he would find it hard to look his teenage daughter in the

eye, if (having studied the question) she asked him why he had not done his utmost to support energy-saving measures such as CHP, and if he had been unable to give a satisfactory reply. He hoped that he had at least done his best to persuade people to look closely at the benefits of CHP and its practical applications. People in the CHPA were not too concerned about whether or not energy was conserved by means of micro CHP, industrial CHP or city-wide CHP. The important point was not to throw away energy at a rate greater than the total output from North Sea gas production.

REAR ADMIRAL P.G. SHARP (Honorary Member, NSCA) joked that for years he had wanted to ask a question during conference discussions but as Secretary General had been unable to do so. He understood that Dolphin Square in London had been connected to Battersea Power Station in a CHP/DH scheme and he wondered what CHP schemes were currently in operation.

He considered that while most people would support the concept of CHP, it was no longer normal to have large power stations situated in the middle of cities and residential areas. He asked how far the heat from power stations such as Didcot or Drax could be transmitted.

MR. ATKINS agreed that the Dolphin Square scheme was well known. When the Battersea Power Station had been closed, the scheme had been taken over by a company, Associated Heat Services Plc, who had refurbished the boiler house and now provided a heat only supply there.

This company had won the bid against a very strong lobby. Several companies had been involved in making bids for an alternative use for the Battersea Power Station. As to other schemes in the country, he drew attention to two such, giving credit to the CEGB in general and John Lycett in particular for the 15 MW scheme at Hereford which had been initiated by the Midlands Electricity Board and which had turned out to be extremely successful, especially after the drop in oil prices. His latest information about the scheme was that the Midlands Electricity Board were

embarassed by the amount of money they were making from it.

Another 24 MW scheme was developing at Fort Dunlop. This was designed as a large-scale CHP/DH station, and the holding company and Birmingham City Council were negotiating with the MEB for the supply of heat - there was a large amount of heat available. Altogether, there were approximately 174 existing CHP schemes in the UK, between them contributing a fairly insignificant amount of power. (It had been estimated that private generation represented only some 12% of total electricity consumption.)

Turning finally to the point about the location of power stations, he referred to Continental experience and the Belfast Study looking into the possibilities of heat supply from the Coolkeragh Power Station, about 17 kilometres from Belfast. Distance was not an insuperable problem as long as the system design was carefully thought out. He hoped that in future the government would encourage the design of CHP schemes linked to any new nuclear or fossil fuelled power stations. It would be a question of siting them somewhere where they could be connected to fairly large conurbations.

CLLR. TERRY SHORT (Nuneaton & Bedworth BC & Midlands Joint Council for Clean Air & Noise Control) said that he had been intrigued by the costs of the micro schemes. A figure of £100,000 had been quoted, giving a saving of about 90p per hour. His "back of envelope" calculations indicated a pay-back period of about 11 years. On that basis, he would imagine that any private venture would be undertaken only by a very long-sighted person: most such ventures he would see as linked to large combines of hotels, or health authorities. Some hard selling would be necessary to persuade people to accept a pay-back of 11 years, particularly if the engines only lasted for three years - that implied at least three engine changes during the pay-back period.

As to the large schemes, he expressed surprise at the inefficiency of the very large power stations, still constructed with great cooling towers. He appreciated the

savings to be gained through large-scale CHP schemes but drew attention to the enormous initial investment in trench digging, installation of pipe work etc. It was such a major engineering undertaking that some political decision was needed to get such schemes off the ground. His experience with the smaller schemes was that, once installed and with all consumers paying the same amount, arguments about who used more heat and therefore benefitted to a greater extent started to emerge. Some district heating schemes had actually been abandoned because of bad feeling amongst tenants. The Council had returned to individually metered schemes since people's community-mindedness faded away when it came to paying bills.

He concluded by saying that money had to be found to develop CHP/DH schemes on a national scale, and that such money could only come from central government sources.

MR. GREY explained that the figure of £100,000 would be a typical cost for a 200 kW unit: ie, £500 per kW of electrical generating capacity. He believed that he had mentioned that the average cost of such units was £400 - £500 per kW of electrical generating capacity installed. Some of the information, available free from ETSU, would give the investment cost for each of the demonstration units, the projected savings and the pay-back period. Current experience suggested that the pay-back for the units currently under demonstration was in the region of 2 - 5 years, even after taking into account the full cost of maintenance and engine charges. The figure of savings of 90p per hour had been specific to one set of calculations for a 45 kW unit. The economic analysis of a CHP system was not straightforward - a number of factors had to be taken into account. In addition, the site heat and electrical demands had to be assessed in great detail. But the sorts of figures he had quoted were reasonable averages. Anyone wanting further information about the economic analysis of micro CHP systems was advised to contact ETSU, who would provide suitable published material on how to calculate the benifits of CHP systems. Data on typical initial costs, maintenance costs and studies of individual installations are also available.

MR. ATKINS agreed that the installation costs for the large-scale scheme were a major capital undertaking. He also agreed that a political decision at national level was required in order to realise the benefits of such schemes to the nation as a whole.

As to the attitude of tenants towards group metering, he referred to the excellent comments made by Mr. Ankers and the need to educate the end user. Much of his own time in the past ten years had been spent trying to help local authorities who had encountered difficulties in operating existing district heating schemes. These problems ranged from operational to economic difficulties, let alone the problems with evaporative heat meters. Now, however, the AMA together with the CHPA was preparing a guide for all local authorities. Many local authorities up and down the country faced identical problems and were in effect trying to re-invent the wheel in isolation. Many local authorities had gone down the painful road of removal/ replacement/refurbishment and there was a great deal of information available which would be of assistance to other local authorities faced with the same difficulties. He was currently working on a British Standards Committee Panel on electronic heat meters and was involved in the use of prepayment heat controllers, which was a novel and promising development in the long term for local authorities. He drew attention also to the impending legislation relating to the assessment of district heating charges under which local authorities would be required to make clear to tenants, on request, the basis of their charging method, and to prove that the charges levied were reasonable. The problem would then be that the local magistrates would have to determine what was "reasonable".

There was a great deal of information available to help local authorities, detailing existing schemes which had operational, technical or financial problems.

CLLR. R. GILLIGAN (Halton Borough Council) said that Mr. Atkins had mentioned waste incineration plant and it would clearly be beneficial to recover heat from the incineration of waste. However, in his own Borough, where

such a scheme was being put into operation, the public had expressed considerable concern about the production of dioxins from the plant. He asked Mr. Atkins, as an engineer, what response he would give the public on the question of dioxins from starved-air incinerator plants.

MR. ATKINS said that he was pleased the matter had been raised since it was one that interested him personally. His practice had advised both local authorities and health authorities on the operation of incinerators and he had been particularly concerned about the operational parameters applied to hospital incinerators. He shared the concern expressed by Mr. Don Barnett that morning about the Crown immunity applying to hospital incinerators. Recently a large hospital authority had approached his practice regarding a proposal from the manufacturers of both the burners and the hospital incinerator, to retrofit a new system which would increase the amount of excess air in the secondary combustion zone and reduce the gas consumption by about 40%. The hospital authorities had been very pleased with the proposal but Mr. Atkins had responded by expressing his considerable reservations on the grounds of difficulties posed by dioxins formation. Mr. Atkins had suggested that the hospital should write to their local authority regional engineer for advice but in actual fact there was no official guidance on dioxins available. The only published advice, from the United States and Canada, was that the back end temperatures should be maintained to a level of at least 1000 degrees C and preferably 1200 degrees C. His own advice to local authorities would be that the expertise to deal effectively with refuse incineration plant design, monitoring and installation was lacking in the UK. He believed that such expertise did exist on the Continent and that those in the UK should, if necessary, buy in the expertise and in the long term acquire knowledge themselves.

DISCUSSION - SESSION 4
"AIR POLLUTION CONTROL - SITUATIONS REPORTS"

Speakers: Dr.C.E. Miller, Mr.J.H. Boddy, Dr.D.J. Ball

MR. R.W. LANDER (Chief Environmental Health Officer, Middlesbrough Borough Council), opening the discussion, thanked the speakers for presenting three most interesting papers that morning. He had appreciated the different perspective on planning matters, provided by Dr. Miller's academic background, and expressed his personal concern about the implications of deregulation in relation to planning. Dr. Miller had explained, the Government proposals regarding simplified planning zones were intended to increase efficiency and simplify procedures. But in Middlesbrough, where the unemployment rate was very high - about 29% - and on one estate roughly 90% of the people who were employable were actually unemployed. Clearly, that situation was untenable; but although the Council was anxious to create jobs it was not prepared to do so at any price. Middlesbrough Council took the view that Middlesbrough must not be allowed to become the industrial dustbin of the country.

In general, prevention of environmental problems was preferable to curing them once they had arisen and planning powers provided those preventative controls. Anticipation of problems, and recommendations for their amelioration was far better than resort to statutory action after the event. Other primary legislation dealing with nuisance had only been introduced slowly over the years in order to abate the problems caused by the bad planning decisions of the past.

As to the Government White Paper, "Lifting the Burden", Mr. Lander endorsed the remarks of Mr. Snow from the Chair earlier that morning, when he had queried whether the intention was really to lift the burden or rather to shift it around. In many ways, he considered that the document embodied a political ideology and had probably been designed

to assist many small operators to establish themselves without any bureaucratic restraint. However, Mr. Lander had seen many such businesses start up without the capital necessary to establish trouble-free relations with their neighbours and in many cases the local authority had been left to take remedial action and that in turn had left the company concerned in difficulties. In his view, it would have been better to stop the problem before it occurred.

The Middlesbrough Borough Council had decided to create an enterprise zone in order to attract employment opportunities into the area. As many would know, the Department of the Environment insisted on only minimum restrictions being imposed on firms setting up in enterprise zones. In the majority of cases, normal planning considerations were waived. In consequence, the Borough Council had experienced great difficulty in getting specific exemptions included even in the case of CIMAH sites. That showed the determination of the DOE to insist upon relaxed controls

Some firms simply moved from one site within the Borough to the enterprise zone in order to take advantage of the industrial land grants and rate free industrial/business premises for a number of years. In those cases, no new jobs were being created but instead a derelict site was created in the wake of the move. No-one would take on the former industrial site/buildings outside the enterprise zone. In some ways, the net effect was simply to move jobs around the town rather than create any new jobs.

The DOE restrictions had produced other sorts of problems. Middlesbough BC had been approached about the installation of a hazardous container lorry park. That concept was alarming - lorries grouped together containing a variety of hazardous materials. An accident occurring to one vehicle could have a mushrooming effect and produce a cocktail of chemicals released into the environment. To demonstrate that the problem was real rather than hypothetical, Mr. Lander referred to a particular incident involving a tanker which had travelled up from Kent with a hazardous cargo,and arrived and parked in the centre of Middlesbrough with a load which had become dangerous, having heated up. The tank had not been properly cleaned out before being refilled for its journey and the contamination had caused the over-heating,

which in turn had led to a major problem in the town centre. While a major hazard site had to be registered, there was no such requirement for a lorry park, even for vehicles containing hazardous cargoes. Thus, it was impossible to stop such a lorry park going ahead in the middle of an enterprise zone. Middlesbrough BC had expressed its concern to HSE.

Another project proposal had been from an American firm which had wished to decant hazardous loads from large into smaller drums. These were chemicals associated with cavity foam insulation. It eventually transpired that the chemicals were similar to those which had caused the Bhopal disaster but their original application had simply been for two standard industrial units with no indication of how they would deal with emissions and drainage problems from the works. In both cases, had the Council not owned the land, it would have been in some difficulty regarding imposition of constraints or refusal of these proposals.

As he had indicated, enterprise zones could be very close to sites registered under the Notification of Installations Hazardous to Health and the CIMAH Regulations. Were accidents to happen, their impact would not be restricted to the artificial boundary implied by the consultation ring established by the Health & Safety Executive.

Acknowledging Dr. Miller's references to cases where planning law had been beneficial, Mr. Lander said that he fully acknowledged the benefit of planning controls, and would like to see the regime strengthened rather than weakened, to ensure proper consideration of environmental impact. However, he thoroughly agreed with the Industrial Air Pollution Inspectorate about the undesirability of setting specific numerical standards when approving planning applications: conditions did change, it was to be hoped, for the better.

Turning to the two papers on diesel emissions, Mr. Lander commended the thoroughness with which both technical and smoke emission aspects had been tackled by the speakers. He said that in the past thirty years local authorities had spent considerable sums of money and a great deal of time on implementing smoke control areas and securing controls over industrial emissions. He thoroughly agreed with Dr. Ball that

the time had come to turn attention to further reductions in emissions from mobile sources and that the current conditions were intolerable.

Teesside had a large petro-chemical complex including some nitric acid plants and in the past the Middlesbrough Borough Council had attempted to quantify the impact of those plants on ground level concentrations of nitrogen oxides. They had done this by means of widespread distribution of diffusion tubes on a half kilometre square grid. He and his colleagues had been very surprised to find that although the diffusion tubes had been placed where maximum ground level concentrations from the industrial plant might have been expected, the problems were not attributable to the industrial plant. Road vehicles were clearly the cause of the problems. Wherever there was a hold-up or build-up of traffic, higher levels of oxides of nitrogen were recorded.

Mr. Lander considered that it was generally recognised that the diesel engines gave rise to smoke, odour and noise problems. People were conscious of the filth from the exhausts of lorries, buses and increasingly from cars and taxis. Were vehicles to be properly maintained and operated, such pollution would be minimised. However, the lorry labouring uphill and belching out black smoke was an all too common sight. His own guess was that in such cases the governor might have been tampered with so as to increase power. Both buses and taxis caused problems when they were left stationary with the engine running. He considered that unnecessary pollution from such sources should be declared an offence under the Road Traffic Act. Stricter control of diesel emissions was under discussion within Europe, but it would be some time before new vehicles manufactured to the new standards were on the road and meantime the pollution would continue. Mr. Lander questioned the need for delay, quoting the case of the USA, where lead-free petrol had been available for years and strict emission controls were in operation. European vehicles exported to the United States had to meet the same strict standards. Yet here was Europe apparently re-inventing the wheel and giving tardy consideration to problems already resolved in terms of a determined plan of action. The United States was planning to achieve substantial reductions in diesel exhaust emissions, including smoke, whereas the

standards under discussion within Europe would be considerably more lenient and would not be effective until the 1990s. He considered there to be a strong case for urgent action within the European Community.

He had a further concern, that the deregulation of bus services might bring about a relaxation in maintenance standards, in order to reduce operating costs. He wondered whether there might be yet more smoky buses on the road as a result.

Finally, referring to the role of the police in prosecuting for smoke emission from vehicles in use on the road, under the Construction & Use Regulations, Mr. Lander wondered whether there was a case for approaching the Home Office in order to tighten up on enforcement.

MR. G.R. CHARNLEY (Southampton City Council) referred to page 7 of Dr. Miller's written paper, quoting:-

> "According to the Department of the Environment, the strengthening of statutory nuisance law might lead to a reduction in what it describes as the unnecessary imposition of planning conditions. The crucial issue is that planning conditions are anticipatory in effect and can be used to prevent pollution and nuisance arising. In contrast,statutory nuisance is retrospective in effect and action can be taken only after nuisance has been demonstrated."

Mr. Charnley wished to draw attention to the word "nuisance". In general parlance it meant an annoyance but the statutory definition was "substantial and unreasonable interference in the enjoyment of property". However. he considered that when planning for the future the standards should be far higher than the mere absence of nuisance. For example, if several new noise-producing sources were allowed to set up in an area, each being required simply to avoid nuisance, that would ignore the cumulative effect of the sources in combination, which might produce an intolerable level of noise. He considered the assumption that statutory nuisance legislation, even with preventative powers, could achieve a satisfactory planning criterion was erroneous. He asked whether Dr. Miller acknowledged a difference between

statutory nuisance and a good planning standard, and he drew attention to the book by Dr. Miller's colleague, Dr. Chris Wood, on "Town Planning and Pollution Control".

MR. J. SCHOENEWERK (Siemens AG, Karlsruhe, FR Germany) explained that he was the Sales Manager for process analysers for the UK and the USA. He wanted in his comments to cover that session's papers and also those of the previous morning. He observed that there was apparently neither the impetus of strong public interest nor strong political interest which would serve to secure adoption and implementation of more stringent air pollution controls in the UK. He did not expect overmuch from EEC regulations; the negotiations often produced weak, compromise end results in the form of directives. Once these were adopted, each Member State could adapt them to suit its own legislative and administrative framework and implementation dates were often considerably extended.

His final observation was that many of the research and technical topics relating to air pollution had already been covered in detail in the US ten years previously, and in FR Germany, five years previously.

In his view, regulations on paper were meaningless. What were required were specific implementation plans and routines and, above all, the infrastructure to ensure proper checks on compliance with regulations. Germany had the "grossfeuerungsanglagenforordnung" - the incredible word for regulations applying to large combustion plant - and the TA Luft for all types of plant. Each plant was required to give an emission report to the local authority. He asked whether there was an English equivalent. In Germany, a few spot measurements were required and these were carried out by the TUV - a private supervisory board company, which would be paid by the owner for its services. The local authority would then decide whether the plant was covered by more specific regulations and what particular measurements had to be carried out. He asked whether UK local authorities were trained for the exercise of such controls.

The emission monitoring had to be done according to an approved system and a very stringent test programme -

requiring three months of laboratory tests and three months of site tests.

After the system was commissioned, the TUV would check the whole system, from sampling point, sampling preparation, and through to data recording in a one-week compliance test. Thus, the German Analyser Manufacturers had per force designed reliable, accurate and low-maintenance analyser systems. Thus, whatever regulatory requirements were to emerge in the UK in future, he considered that the analysers from Germany at least would be able to do the job required. Continuous monitoring and recording was essential. The German experience showed that it was pointless to rely on a few spot measurements before the major pollutants were monitored,because then chart recorders would produce miles and miles of paper. There was no point in overloading the local authorities in that way.

CLLR. T. SHORT (Nuneaton and Bedworth BC, and Midlands Joint Advisory Council on Clean Air and Noise Control), referring to the White Paper, "Lifting the Burden", said that it had been widely discussed amonst local authorities. However, the response it had called forth had not been along party lines. Opposition to the thinking behind the White Paper was strong, with support from all parties. He believed that the all-party opposition was stimulated by the perception that the White Paper was essentially anti environment in spirit. People who served on local council Environment Committees, regardless of party, tended to uphold environmental protection and the need to improve amenity and standards for society generally.

One of the main shortcomings behind the White Paper had been the criticisms levelled by government at local authorities that planning departments had been dilatory in granting planning permissions, or too severe in conditioning them. However, his own authority (Nuneaton and Bedworth BC) had been commended for its efficiency in dealing with planning applications and he knew of no instance where that authority had failed to administer planning law effectively and to time. Local authorities generally did not sit on planning applications for the sake of it. They were in the business of creating employment in their area, but <u>not</u> jobs

at any price.

Cllr. Short saw the paper as an attempt to return to out dated and undesirable Victorian values. For example, in his own area extensions to small hosiery manufacturers had been granted by the Secretary of State on appeal, although the works were sited in the middle of residential areas with old style dense housing. DOE's argument was that the works would not create undue problems, and any that were caused could be rectified by the Environmental Health Department. However, the local council knew that the movement of lorries in such residential areas was already creating problems and that an increase in the scale of the works would lead to a greater number of lorry movements, thus increasing noise and air pollution. He considered that the permission granted by DOE to extend the small "backyard" works was also detrimental to the overall development planning within the Borough, as businesses would take the easy option of developing existing works rather than moving to the designated industrial zones.

Another example of DOE interference with the local council's planning was over gypsy sites. His authority had a designated gypsy site, but permission had been sought to establish caravans on the Green Belt, and the planning applications had been approved on appeal by the Minister, on the rather flimsy grounds that the individual concerned wished to establish his family nearby. The net result was an explosion of some 20 caravans in the Green Belt, despite the protests of local residents, the local and the county coucil. Cllr. Short summed up by saying that he feared for the morale of environmental health officers, environmental health committees and local councils in general, faced with government pronouncements such as those contained in "lifting the burden" and with idiosyncratic appeal descisions. Local councils were in the business of trying to improve the environment, and he considered that the Government White Paper ran counter to that effort and did not anger well for the future. He considered that councillors of all political complexions should oppose it.

MR. M. J. GITTINS (Leeds City Council) said that the widespread concern aroused by the Government White

Paper, "Lifting the Burden" was evident from the number of speakers from the floor who had commented on it. While he did not wish to rehearse the arguments put forward by the two previous speakers, he wished to put a particular question to Dr. Miller which related to the latter part of his paper. Dr. Miller had called on local authorities to be "vigilant"; Mr. Gittins pointed out that such vigilance had to be framed in terms of concrete action, despite contrary Directives from central government, such as the White Paper and Circular 1/85.

At Public Inquiries, Inspectors frequently took greater account of government White Papers and Circulars than of the professional views of officers, and the decisions of elected members. He wondered how Dr. Miller saw the vigilance for which he had called being translated into reality.

CLLR. L. HARRISON (Wakefield MBC) said that he was usually in the position of criticising his own authority at Clean Air Conferences but on this occasion, because Wakefield had an enlightened Chairman of Environmental Health, he was pleased to report that Wakefield's smoke control programme had moved back into gear (not perhaps top gear as yet, but it was getting there).

That aside, however, Mr. Harrison had been intrigued by the historical perspective on pollution problems thrown up by the discussion at Conference so far. He recalled that at an earlier (1973) Clean Air Conference one Birmingham representative had said that since they had successfully tackled smoke control, the time had come to move on to smoke from road vehicles. And the previous day there had been reference to the cocktail of pollution on Teesside, the effects of which had been exacerbated by the local topography. The message had been that planning should be carefully used to prevent such problems arising. On the question of enterprise zones, he agreed that these were needed but questioned the adequacy of environmental controls exercised via planning conditions in enterprise zones.

In a joking reference to the status of nuclear free zones during the Chernobyl incident, Mr. Harrison said that some

people had regarded the declaration of nuclear free zones as a protective measure against the fall-out from Chernobyl, and had declared that any Councillor not supporting the policy of nuclear free zones was irresponsible.

Accidents, such as the one that had occurred recently at Middlesbrough, were another question again and he felt that every effort should be directed towards preventing such accidents or helping ensure the safety of people surrounded by large industrial complexes who might be subject to such accidents, however small, on a regular basis.

DR. C. E. MILLER, responding to Mr. Charnley's question, said that he certainly acknowledged the difference between a good planning standard and the minimal requirement of preventing nuisance. He believed that planners could do more than simply prevent nuisance. The really important factor was that the setting of planning conditions took place in advance of development: local circumstances, the state of technology, the employment implications could all be considered. The setting of planning conditions was determined by locally elected council members, on the advice of their officers; they took the decisions, on behalf of local rate payers. In contrast, the successful application of nuisance legislation was dependent upon magistrates. It was a quite separate branch of criminal law. As well as being anticipatory in nature, planning conditions could be used to assist the implementation of any policy within any statutory development plan.

Referring to Mike Gittins' question, Dr. Miller said he was somewhat at a loss as to how to advise him. Mr. Gittins had gone to the heart of the matter: once local authorities were stripped of their planning powers and deprived of anticipatory control over pollution sources, their flexibility would be substantially diminished. He would make one point: where the Department of the Environment might be adamant, the courts might be more sympathetic to the local council's case. Decisions which went to planning appeal could be overturned by the courts, if the circumstances were such that the Secretary of State or his planning inspector had misinformed themselves as to the law. There had been cases where the courts had been far more prepared to allow the

environment to be seen as a proper consideration in the planning process. The essential problem was what constituted a "material consideration" in the planning sense. Since central Government did not fully define the term "material", the political climate influenced the definition of this legal term. Whether or not pollution was a material consideration again had never been properly spelt out, and decisions on the matter depended upon the political climate. The Courts had usually been more ready to accept that pollution was a material consideration, but the judgments of DOE inspectors had varied. Recently, the trend had been against accepting environmental and pollution matters as material consideration.

The position of local authorities wanting to use planning law to prevent pollution would have been strengthened had they been prepared to insert pollution policies into development plans. Dr. Miller acknowledged that the obvious response was to point out that Central Government had not been particularly sympathetic to the inclusion of such policies when development plans were being prepared back in the 1970s. However, where a structure plan included pollution policies, the local authority's power to excercise some control over polluting developments was greatly increased. Dr. Miller recommended that the opportunity should always be taken to insert pollution policies into revised structure plans.

MR. J. H. BODDY, responding, wished to make one comment concerning Mr. Lander's reference to Europe re-inventing the wheel. He drew attention to the origins of vehicle legislation both in the United States and in Europe. It sprang from two different sources. In the States, legislation on vehicle emissions had been promulgated in response to the California type smog; in Europe the root cause had been excessive carbon monoxide in city centres. These different root causes had influenced the approach to the different test cycles used in the United States and in Europe. While the whole pattern of concern about road vehicle emissions was changing, it was not so much a question of reinventing the wheel but of recognising that different things needed to be considered today. Smoke, not only from diesels but from all vehicles was now a matter for

concern. A badly maintained petrol engine burning large quantities of lubricating oil would emit quite a lot of smoke. That could be just as carcinogenic, if not more so, than the smoke from diesel fuel. At the same time, the problems of manufacturers in obtaining ever higher standards had to be acknowledged.

Picking up on another point made during the discussion, about the parking of heavy vehicles in city streets, Mr. Boddy said that this had to be avoided. He emphasised the point he had made in his presentation, that the government should be urged to legislate for the restriction of heavy vehicle traffic to certain roads, avoiding city centres and residential areas.

DR. D. J. BALL wished to comment on one point made by Mr. Lander. He had agreed with 90% of Mr. Lander's remarks, but took issue with his statement that smoke emissions would be minimised if diesel engines were maintained properly. Dr. Ball said that he completely disagreed with that view. The smoke emissions would be less obvious, but not minimal. The real problem was that the standard itself was inadequate, based on outdated considerations which simply did not address the effects of smoke emissions on health or soiling of the environment. What was required was a proper standard based on a realistic assessment of the effects of diesel smoke. Such an assessment had been carried out in the United States and, as he had shown in his presentation, the United States was opting for a far more stringent level of control. Thus, he considered maintenance to be rather a red herring. Without a decent standard, maintenance of the vehicle would achieve little.

As to the interest of the Police in enforcing smoke control under the Road Traffic Acts, he found it difficult to blame them for their attitude that such enforcement was a waste of time. The Police had other things to do, and it was extremely difficult for them to bring a successful prosecution when the basis for prosecution was a subjective assessment of whether or not the vehicle was causing a nuisance by smoking. Again, the proper basis for enforcement would be established if the initial smoke emission standard were sound.

Dr. Ball expressed his interest in the remarks of Mr. Schoenewerk from Siemens. He agreed that all his points about the mechanisms for proper appliance monitoring were valid, and added that almost none of those systems existed in the UK at present. Dr. Ball considered that the Germans had a far more professional approach towards air pollution control, using the latest scientific methods.

As to the lack of public pressure for improvements in air pollution control in the UK, Dr. Ball considered that this might have something to do with the electoral system. First past the post meant that no green candidate would ever be elected in the UK in the foreseeable future.

DISCUSSION - SESSION 6
"NOISE"

Speakers: Mr. J.D. Clegg, Mr. B. Whittaker, Mr. K.G. Kaufman, Mr. D. Romaine, Mr. A.J. Gibbon, Dr. M. Trinder.

MR. W.C.B. ROBSON (BEHO, Darlington BC and Hon. Secretary, NSCA Northern Division) opening the discussion, commended all the speakers for their first class presentations. He expressed the view that most noise annoyance in society was due to people's thoughtless behaviour, and he congratulated the speakers for highlighting that point. The paper by Messrs. Clegg and Whittaker had listed in rank order the top ten sources of noise nuisance for the UK, six of which were examples of community noise, capable of remedy by the individual. It was not necessary to use legislation to deal with overloud radio and TV sets, shouting neighbours, and slamming car doors. All that was required was education.

Mr. Robson said that Geoff Kaufman's excellent paper had shown what could be done to minimise noise levels in flat conversions. He had suggested that planning officers should encourage applicants to contact the environmental health department before submitting their planning applications. Mr. Robson took issue only with the voluntary aspect of the suggestion - he believed that such a reference to the environmental health department should be mandatory. In his own authority he had persuaded his planning colleagues that such discussions should take place as a matter of course and he hoped that this would become general practice in other authorities.

Turning to the presentation on alternative noise abatement zones, Mr. Robson said that he and David Romaine had something in common. Neither of them could remember sanitary inspectors with bowler hats and drain rods - the

modern equivalent always seemed to be equipped with sound level meters. He commended Mr. Romaine's approach to "alternative" noise abatement zones as interesting and overdue: the case for a more simplified monitoring network, which would lead to a more practical and less labour-intensive approach. However, Mr. Robson wondered what reaction industrialists had to this proposal and whether it would be capable of withstanding legal debate.

Alan Gibbon had dealt lucidly with the ubiquitous problem of motor cycle noise, one which was exacerbated by the difficulty of enforcing and testing the legislative standard. 2865 motor cyclists had been found guilty of noise offences in 1983. That tally could not be regarded as a success: indeed, it was an indictment of the legislation. Mr. Robson considered that in the light of the annoyance produced by motor cycles, the prosecution figure should have been four times as great. He regarded the education of motor cyclists on noise as a priority. During the "Darlington Quiet Town Experiment", a poster of Barry Sheen had been issued to purchasers of motor cycles, with the caption: "If I can win without a din so can you". The motor cyclists had appreciated the message, had identified with their folk hero and had tried to emulate him.

Turning finally to the presentation by Dr. Trinder on anti-noise, Mr. Robson said that he had found this totally absorbing and he extended his warmest congratulations. That presentation had revealed that the technological know-how existed to design out the worst excesses of noise. It had been an exercise in the art of the possible. The Darlington Quiet Town Experiment, which ran from 1976 to 1978, had been initiated after prompting by the now defunct and much lamented Noise Advisory Council. One of the members of the working group at that time had been a youthful Don Barnett (one of the speakers at the 1986 Conference). The Quiet Town Experiment had cost the Government £26,686; Mr. Robson said that it had cost him personally a healthy head of hair. The experiment had been an educational success; noise sources had been identified and people had been educated about the causes of noise in and around Darlington. But the Government had not extended the scheme to other towns and cities, and the Noise Advisory Council had later been dissolved. Mr. Robson expressed his

great pleasure in the fact that the National Society for Clean Air had formed its Noise Committee under the chairmanship of Hylton Dawson. The presentations by the various Noise Committee members at the Conference were in effect the first fruits of the Committee's labour and he believed that the positive response evoked by the session augured well for the future success of the Noise Committee and its work. However, he warned the Committee against re-inventing every part of the wheel and counselled its members to build upon work already done, to consult the report of the Darlington Quiet Town Experiment, which contained valuable information on social surveys, revealing public attitudes to noise. The report also identified what exactly noise in the community consisted of and showed what educational methods were devised and used for the Darlington Experiment, with great success. Amongst these, was the first teaching pack on noise for children in primary schools.

Mr. Robson concluded by saying that much remained to be done in the control of community noise and the most important message to get across, to delegates at the Conference as well as the general public, was that everyone was capable of being just as noisy as their irritating neighbours. He believed that the role of education in noise control would be given far greater emphasis in the next few years. Finally, he thanked all the speakers for their contribution to a great Conference session.

MR. K.G. KAUFMAN, responding, said that he entirely agreed with Mr. Robson's remarks about the absolute need to consult with environmental health departments over planning applications. He found it reassuring that a highly respected member of his profession should feel as he did on this point. Indeed, he considered that there were many other aspects of local authority work - eg entertainment, recreation and highways - where liaison between the officers responsible and the environmental health department would have similar benefits.

MR. D. R. ROMAINE said that the attitude of industrialists to any pollution problems depended largely on

the way in which the proposal was put to them. The big stick often failed but if the reasons behind the proposal were carefully explained, and the environmental health officer was prepared to consider their reasonable objections in turn, then new types of control could often be seen to be of mutual benefit, to both the industry and the local authority concerned.

DR. M. TRINDER said that he had been struck in all the discussions so far by the crucial importance of money. Ten years earlier, when he had been working as an acoustic consultant, he had been involved in the problem of sound insulation and from the presentation that day by Geoff Kaufman he could see how little progress had been made over a decade. With reference to his own subject, the application of active noise control, he said that the technique had been successfully demonstrated; it did work, but while there were plenty of ideas for its application, few had been developed because progress was hampered by lack of money. In the UK further research was receiving minimal backing so it was necessary to turn to other sources for finance, notably to the United States.

MR. J.D. CLEGG, picking up on Mr. Robson's remarks about education, referred delegates to a point on page 17 of his joint paper, that people only became concerned about noise when they suffered from it themselves and that an education exercise was needed as a permanent component of life. Indeed it was of paramount importance in almost every aspect of environmental health.

He and Brian Whittaker had certainly drawn on many sources in preparing their own report. Indeed, he was reminded of a quotation on Brian Whittaker's office wall, to the effect that copying one bit of information was plagiarism, copying from ten sources was research!

MR. B. WHITTAKER agreed wholeheartedly with the point made earlier about the need for planners to direct applicants to the environmental health department. He personally placed planners at the top of his list of those requiring

education.

MR. R.C. WEBSTER (Leicester City Council) directed his first question to Mr. Kaufman's comments about party wall insulation in first floor flats. He had suggested that putting living rooms/kitchens next to bedrooms on adjacent premises should be avoided. However, Mr. Webster felt that this was not always possible, especially in the smaller type of terraced house, just one room wide. Mr. Kaufman's suggested remedy had been a specified insulation standard for the party wall. At present, most people specified the latest Building Regulation standard in such cases, which was the equivalent of a 9 inch solid brick wall. However, this already existed in the Leicester properties with which he had been dealing recently, which meant that any such specification would be meaningless. He asked, therefore, whether it was time to go beyond the equivalent of the 9 inch solid wall standard, especially as it might have a 45dB insulation at best.

He felt that the real question was whether or not it was reasonable for somebody in their own lounge to play a hi-fi system at a typical level of 80 dB(A). Allowing for the party wall insulation, that could result in 35 dB(A) in next door's bedroom. Given a typical background noise of 20 dB(A), it would be an increase above that ground level of 15 dB(A), and therefore likely to constitute a statutory nuisance. Was the real requirement, perhaps, for another 10 dB of insulation, which would entail a great deal of expensive work to be done to the wall. If so, he wondered what sort of work Mr. Kaufman would recommend.

Turning to noise abatement zones, Mr. Webster believed that Leicester City Council had adopted a novel approach. Leicester was just beginning a new programme of noise abatement zones. Mr. Webster still maintained that multi-point measurements were necessary. Because he agreed with Mr. Romaine that such measurements could be very expensive, he proposed using a vehicle which could pull in at least six channels at once, thus overcoming the problem of the noise level changing while the position was being moved. But he had discovered that there was no ready-made system available. A typical purchase two years

ago had been six B & K 4426 models, at £6,000 each (or £8,000 for the latest models) - an investment totalling about £50,000, even before buying the vehicle to accommodate all the instruments. But B & K had just developed a new system, and Mr. Webster believed Leicester City Council were the first to purchase it. This used the new 2231 digital sound level meter, linked to a set of Epson small computers which were just £500 or so each. While the system was not yet off and running, it had been developed at something less than £3,000 per channel, which was fairly reasonable.

Mr. Webster's question to David Romaine concerned policing the zone once it was established. David Romaine had suggested that all the measurements should be repeated when policing the site but Mr. Webster preferred to take more measurements in the first place, and then police the site using just one measurement. If the resulting level indicated that the design criteria were being exceeded, then clearly the whole set of measurements would be repeated. Initially, though, policing would be via a single spot measurement over a very short period of time.

Finally, Mr. Webster asked Alan Gibbon about non-standard silencers and the proposal to make these illegal. But he wondered how to tackle the problem of exhausts manufactured specifically for racing purposes but bought and fitted to ordinary motorbikes.

MR. KAUFMAN, responding to the questions about sound insulation, said that a great many points had been raised. However, the essential point about planning made in his paper had been to ask initially whether the property under consideration was really suitable for conversion. Most applications for flat conversions related to large dwellings, which could be converted to form a number of smaller dwellings. It was less usual, according to the survey conducted by the NSCA, to find conversions dividing one room per floor of houses into two one-roomed flats. He believed that if an application was for the sub-division of an initially small unit, the local authority should think carefully before giving its permission for the conversion to go ahead, however conditioned.

As to the question regarding the specific treatment for party walls, Mr. Kaufman referred Mr. Webster to the forthcoming NSCA publication, Part 2 of its Report on Sound Insulation in Flat Conversions, which would deal extensively with the desirable sound insulation standards and the technical means of achieving them. The first part of the Society's report had dealt with the problem, and the second part would explain how to control it. Alternatively, Mr. Kaufman offered to discuss the matter in detail after the session ended.

MR. ROMAINE said that the question of policing an NAZ depended entirely on its nature - obviously, a single premises zone with a limited number of noise sources could be policed by taking a single measurement. This would be impossible for a large zone with a lot of sources in a residential area, for example. As he had emphasised in his paper, however ingenious and sophisticated the measurement system used, measurements should only be taken when and if necessary. He was delighted, and somewhat envious, to learn of Leicester's willingness to invest in such equipment but questioned whether the expenditure was really justified.

MR. A.J. GIBBON said that his presentation had referred exclusively to legislation concerning motor bikes used on the roads. Current legislation specifically stated that certain silencers which were not of the required standard should not be fitted to bikes for use on the road. These could be marked, "Not for road use". As to the use of racing bikes on a track, or even on land, then control was exercised through planning or, where the planning permission had already been granted, through remedial control by the Control of Pollution Act. He considered such cases to be relatively easy to deal with. Although he was no expert on motor cycle design, he suspected that the requirement for power output would conflict with the requirement for low noise output and that exhausts designed for racing bikes might be intrinsically noisy.

MR. P.W. SAGE (British Coal - Coal Research

Establishment) said that Dr. Trinder had mentioned the use of prototype active noise control systems for stationary and mobile sources but he sought further details about the future availability of the equipment, and likely cost.

DR. TRINDER said that the systems designed had been installed in various prototype applications over a period of five years or longer. His unit was currently working with companies in the UK and abroad which were looking to exploit the technology. Some particular companies in the United States were hoping to have systems available, on the market, in one or two years' time. Physical size was obviously a point of concern, although not a problem for stationary applications. For vehicles and moving plant, then size became an important consideration.

As to cost, while the systems were at present by no means cheap, it was a question of supply and demand. If the demand was for the systems in quantity, then prices would come down.

As to what was an acceptable price, a passive attenuation system was marketed by a local company, T.I. Silencers, and Chessicks, Bainbridges etc. were able to manufacture systems for £20 or so. It would be a long time before active noise control could compete with those prices, so it was necessary to look closely at the particular application. Initially, the systems would cost hundreds rather than tens of pounds. Nevertheless, manufacturers both in the UK and abroad were very interested in the technology and, although that interest might have been stimulated by concern about possible competition to their own passive noise control systems, he felt that it had very positive applications to be exploited.

MR. J.L. FEAR (North West Leicestershire District Council) began by saying that he recalled the old sanitary inspectors with affectionate respect, particularly those such as Harry Priestley, formerly Chief Sanitary Inspector in Blackpool, a tower of strength in the profession and Freddie Mills of Stockport, who had once remarked to him, "Don't believe anything that you hear and only believe half of what you see", a cynical but true comment on our relationships

with our various clients.

Turning to noise matters and motor cycle noise in particular, Mr. Fear said that North West Leicestershire had its share of problems with the Donington Park race circuit in its area and the full quotient of young men on 125 cc bikes. Actually, the motor cycle racing events at Donington Park caused little noise problem, because all the events were governed by the Auto Cycle Union's own rules on silencing. Noise output from all bikes racing on the track had to be checked by means of a static test. He asked Alan Gibbon why such a static test was not applied to ordinary bikes on the road when it was used for racing bikes. The racing bikes were revved up and the noise level measured at 18 inches' distance and an angle of 45 degrees. He saw no reason why such a test should not be applied to ordinary motor bikes either at the roadside or at the nearest police station.

Turning to the attitude of mind of motor cycle buyers, Mr. Fear asked whether Messrs. Clegg and Whittaker had examined that point during their survey. He personally believed that most young men bought the most brightly coloured and the noisiest bike they could find. The attitude paralleled that of spectators at Donington Park race track - if all the noise was eliminated at those events, no-one would go to watch them.

As to the proposed legislation applying particularly to silencers, Mr. Fear doubted the effectiveness of such measures. It could be made requisite for silencers to carry the kite mark and be stamped with a particular BS number, but that would not necessarily be a guarantee since the systems were sealed which precluded a thorough investigation of them once in use.

A particular problem in North West Leicestershire was motor bike scrambling. Most of the clubs operating scrambles were fairly responsible and they set limits as to the noise output from bikes taking part. No planning permission was neeeded if events were held less than fourteen times a year - which was still a great many occasions on which to inflict noise on nearby residents. His authority had come to an agreement with one particular club that they would only hold five

events a year. The agreement was currently up for re-negotiation and, knowing this, residents had started making complaints once more but the case was put to them that it was preferable to secure a limitation on the number of events rather than put up with the noise every third or fourth weekend.

MR. GIBBON said that the survey he had referred to had been carried out with the assistance of colleagues from the Derbyshire Advisory Council for Clean Air and Noise Control and they had together decided that the next survey would be timed to coincide with the meeting at Donnington Park race track. As to the scope for a simple roadside test, Mr. Gibbon felt that EEC Directive 1015 provided for such a test, similar to the one used in the survey he had described. There were still problems, however. The position for the test had to be carefully judged. There should not be any reflecting surfaces and one problem that could never be overcome was noise contribution from external sources - passing lorries, and even other motor bikes.

If the noise level from a motor bike was around 80 dB(A), and a lorry came along with a noise output around 85 dB(A) then there would be an additive effect, which would be picked up by the instrument. That was why he had mentioned the possibility of using mobile testing booths. These would remove external noises. The House of Lords Select Committee on the European Communities (Environment) accepted in its report on motor cycle noise that further research on testing was necessary to produce a simplified test, certainly to overcome existing problems. Since the police officer had to stand up in Court and give evidence which would be accepted by the magistrates, the system had to be as simple and acceptable as the breathalyser so that there was no possibility of a defence based on erroneous police testing.

Turning to the point about tampering and the implications of proposed new legislation, Mr. Gibbon said that the proposals related only to the standard or replacement exhausts and could not prevent tampering with the exhausts or, indeed, false labelling with inadequate exhausts; but the new legislation should enable police officers when visually

inspecting motor bikes to know whether or not they were dealing with an acceptable exhaust, according to its marking. He knew from his own experience how difficult it was to tell whether the exhaust was adequate at present, without dismantling. In the end, of course, the problem of tampering with the exhaust could only be put right by means of extensive roadside testing using an improved, simplified procedure.

MR. WHITTAKER said that their survey had not examined the motives of those young people who purchased motor bikes, to explore why they bought the particular models. He agreed that factors such as colour and noise output were probably attractive features for the young purchaser. The MACCANC survey had really been concerned with establishing just how noisy and annoying motor cycles were, set against other noise sources. The next step was to find remedies to the identified problems.

Returning to the previous question raised by Mr. Webster on sound insulation in flats, Mr. Whittaker hoped he could help by passing on some of Bolton's experience. Some years previously he had been involved in two planning cases where terraced houses, two up two down, had been converted into flats without planning permission. The planning enforcement officers had uncovered the two cases and their immediate reaction had been to require those responsible to apply for planning permission. Because there had been complaints about noise from neighbours, his opinion as an EHO had been sought and his view then, and which he still held, was that it was totally unacceptable to convert such properties into flats. He considered that party walls in those situations simply could not cope with the different use and requirements of, on one side a bedroom and on another side a living room. People could not even enjoy normal lives in privacy, let alone play 15w per channel hi-fi systems with impunity. The Bolton Environmental Health Department now advised against all such planning applications. However, because there were other issues in planning permission apart from sound insulation, the Planning Department might still be minded to approve the application. If so, then the Environmental Health Department would recommend that sound insulation measures should be applied. They would

advise the BRE-type methods for floors and walls. Mr. Whittaker added that British Gypsum had considerable experience in the field, as had Glasgow Environmental Health Department.

To complete his story concerning the original two terraced houses, Mr. Whittaker said that on the advice of the Environmental Health Department, accepted by the Planning Department, both applications had been refused and on appeal, both appeals were turned down because of noise intrusion.

MR. J.J. BEAGLE (NSCA, London & South East Division) said that he had considerable experience of noise abatement zones in his former employment with the London Borough of Hammersmith. That authority had the dubious distinction of having been the second in the country to have created a noise abatement zone, during the 1970s. He had approached the creation of NAZs as he would have done the creation of smoke control areas, dividing the authority up into six quite large areas and creating one zone each year. The first had been quite large - 580 acres and 123 premises.

The first problem to arise was an appeal against including launderettes in the list of classified premises. That took a year to resolve. The next problem was in the field, experiencing difficulties in taking readings at various measurement points due to traffic noise interference. Eventually, he had had to obtain a special dispensation under the 1976 Regulations to proceed on the basis of a scientific assessment of the source noise, which had been masked by traffic noise. That process had taken another year or so. As a result of all these delays and complications, Mr. Beagle had formed the opinion that NAZs were not worth the time and trouble involved in setting them up. This had coincided with the imposition of more severe financial restraints upon local authorities and noise abatement zones had gone into cold storage and had not yet been revived.

He expressed his sympathy for David Romaine's efforts to find a less cumbersome and more effective alternative system and he asked whether it would be possible to deal on

a case by case basis with individual classified premises and give them either the full or a modified treatment, so that over a number of years the local authority area would perforce become one vast noise abatement zone. To supplement such a policy, he suggested that works which were the subject of a new planning application should have the NAZ treatment as soon as the permitted use came into operation. It would be a form of creeping noise abatement zoning.

Turning to public attitudes toward noise and the MACCANC survey,Mr. Beagle said that the bane of many EHOs' lives in London were the all-night or all-weekend parties. Investigating complaints involved the EHOs not only in measurements but in physical risks - so much so, that they usually required the accompanying presence of the police who had many other calls upon their time. While London had a great deal of noise from traffic, it almost appeared to be an accepted part of life and it was the noisy parties which were unacceptable. He wondered whether perhaps the North West was lucky enough to escape that sort of nuisance, if motor cycles had emerged at the top of the annoyance rankings there. But if parties were a problem in the North West, he asked how this was tackled.

MR. ROMAINE said that Derby had tackled noise abatement zones in bite-sized lumps. Both its zones were single premises and he thoroughly approved of the policy of creating many single premise noise abatement zones to develop an area which contained at least the noisiest sources as classified premises. He believed that it was not a question of modifying the legislation, but of interpreting it in a slightly different way. Their second zone had in fact gone to appeal and the Secretary of State had confirmed that creating a single premise zone was acceptable. If a minimal number of measurement points were used, the costs would be kept down.

Turning to party houses, Mr. Romaine said that it was an occasional problem in Derby. Recently they had been lucky enough to find equipment left in one house, which they had promptly "taken into safe keeping" which had the effect of upsetting the party thrower and causing him to move his

partying activities into another area.

MR. CLEGG said that in the North-West areas with which he was familiar, the house party problem had not reached such proportions as to require that a special strategy be devised to deal with it. EHOs in the North-West were, however, aware of the London problem, and he suspected that one of the factors influencing decisions as to whether or not to apply for jobs in London was whether they would involve the officer spending time on the party patrol.

MR. T.J. EVERETT (Swansea City Council) said that Geoff Kaufman had quite rightly pointed out that new buildings were covered by the 1985 Building Regulations, whereas flat conversions were not and had suggested that the solution would be to bring flat conversion under Building Regulations control. However, in Swansea, which had had a number of Housing Association Conversion schemes, there were also significant sound insulation inadequacies with new build estates, particularly semi-detached housing and link schemes.

His authority had found great difficulty in enforcing the Building Regulations in practice. Sound insulation was not one of the statutory inspections listed in the Building Regulations and often the Building Control Officer would not examine the party walls and/or floors until after the construction had been completed. An assessment of sound insulation quality was very difficult when relying only on a quick visual check. In Swansea, building control was actually part of the environmental health department so that good liaison between the two arms was easy to secure. Even so, they had encountered difficulties.

The first was the problem of poor workmanship; the ability of any structure to attenuate sound would depend critically upon the quality of the construction works. The slightest of gaps in the blockwork or the condition of the plastering could significantly affect the ability of the structure to attenuate the noise across it. The second problem encountered was that materials were frequently changed on site from the original design specification. Because sound

insulation was not one of the statutory inspection stages in the building control process, the main check would be at the beginning when the plans were deposited. The plans might comply with the Building Regulations and so be passed but later they could be changed. An example would be where wet plastering was replaced by dry lining, which could make sound insulation problems worse rather than help to attenuate noise.

His comment, upon which he sought Geoff Kaufman's observations, was that while securing Building Regulations control for sound insulation in flat conversions would be a positive first step it was by no means the entire answer, and enforcement of an adequate standard would depend on how well the structure could be tested after construction. Carrying out the full range of testing for sound insulation was complex, time consuming and costly and was therefore impossible to do for every single new building or conversion.

MR. KAUFMAN, responding first to the previous question about parties, said that while it was true that the North-West did not have the extensive shebeen type problem, the region suffered from a growing number of complaints about domestic noise generally and particularly from radios, hi-fi units etc. In 1969 he and his wife had purchased a hi-fi unit of some 2 watts per channel whereas nowadays people purchased units of 50 watts per channel so the potential for noise output had increased enormously.

Complaints were increasing, particularly at night, and he felt that local authorities had a duty to investigate those complaints when they occurred, preferably at the time the complaint was made, as it was useless to go round to the complainant's house the following day and try to assess whether or not nuisance had occurred hours after the event.

Turning to Mr. Everett's question, Mr. Kaufman agreed that the "deemed to satisfy" clause in the Building Regulations was fraught with difficulties. He had found on many occasions that new builds did not comply with the BR

standards when tested after construction. Dr. Utley of BRE had indicated to the NSCA Noise Committee that up to 50% of new builds did not comply with the Building Regulations. In the North-West, the figure was even higher than that - 75% of new builds tested did not comply in practice, even though technically they met the requirements of the Building Regulations. Mr. Kaufman understood that there were moves afoot to specify a simplified method of testing, which might help matters. He thought another option might be to persuade the National House Building Federation Council to require their member builders to install sound insulation to a sufficient standard with proper supervision of workmanship. With the kind of price put upon new houses at present, purchasers would be entitled to expect not just that the plans met the Building Regulations standard, but that the construction complied in practice.

MR. CLEGG added that the difficulty with poor quality sound insulation in walls was that it did not reveal itself until the noise problem occurred, once the building and adjacent buildings were occupied. Testing of new builds in France had revealed a similar level of failure as had been demonstrated in the UK. The remedy in France had been to require the testing and certifying of all new constructions, after which the pass rate went up to 90%.

CLLR. J.C. BLEWITT (South Oxfordshire District Council) recalled that a speaker at the 1985 Clean Air Conference had cast doubt on whether noise could truly be regarded as a health hazard. The 1986 session on noise had confirmed Cllr. Blewitt's opinion that noise was both a social and a health hazard. He commended the NSCA's booklet, "Noise & Society" and called for an enhanced educational effort from all sides, directed both to schools and to the community. Such a campaign should be directed both to schools and the community at large. Such a programme would obviously put pressure on environmental health departments, which in turn would require further finance from central government.

Reflecting on the comment that only 34% of people actually complained about motor cycle noise, Cllr. Blewitt considered that this was due to a tolerance built up in society over the

years because of lack of action. People would not complain if their complaint produced no result. As to prosecutions, Cllr. Blewitt felt that the Courts would always judge a case according to its merits and that the evidence would have to be well founded and well presented to succeed.

There were pitfalls in tackling this source in isolation. Cllr. Blewitt considered that traffic noise in all its forms should be tackled on a broad front with a coherent strategy; otherwise, there was a danger of it appearing that the older generation were getting at the younger generation (those particularly fond of motor bikes) which could be very counter-productive.

MR. CLEGG said that his summary observation would be that much of what had been said during the session had been a gathering together of existing knowledge. Local authorities knew what the problems were and many of the answers but he found it most depressing that the Department of the Environment was giving no encouragement to local authorities to get on and tackle noise control on many fronts, a job that urgently needed to be done.

MR. WHITTAKER said that there was no doubt that noise could damage health. People were affected by noise to the impairment of their social well-being. That fell within the WHO definition of health. Yet, in other environmental health matters, EHOs were all too often asked to prove some adverse effect upon health. That was easy to demonstrate when dealing with infectious diseases but rather more difficult when dealing with noise and the more "sophisticated" pollutants.

On the point about planning, he concurred with the view that industry and housing should not be put next to each other. However, he considered the view that planning could prevent any problems to be erroneous. Planning was simply a set of rules and regulations and if a particular condition or objective did not fit within those rules and regulations, planning would not help. The only solution was to learn the planning system inside out, avoid becoming enmeshed in the rules and regulations and to keep sight of the original

objective.

MR. ROMAINE also addressed the point about planning to keep industry and housing apart. He thought that such a goal might be achievable in an ideal world, but all over the country industry and homes already existed cheek by jowl and controls were needed to cope with existing problems. Careful planning could help to avoid problems in the future.

MR. GIBBON said that it was not his own or the NSCA's intention to "bash" motor cyclists. The aim was to educate. He had been struck, during the survey he had undertaken, by the close fellow-feeling between police motor cyclists and the motor cycling members of the public. Motor cyclists were a breed apart, and there appeared to be an instant rapport between them, whether civilian or police. Give the police practical and simple enforcement powers, and the problem would be solved with only a few "bashed" motor cyclists.

MR KAUFMAN considered that greater emphasis should be placed upon prevention rather than control of pollution, including noise. Secondly, he thought that the European Year of the Environment would provide a golden opportunity for an educational campaign, explaining to schools and youth organisations what environmental health departmants tried to achieve through their work on noise and other pollution problems.

DR. TRINDER concluded that noise was clearly a nuisance by definition. He did not regard it as a health hazard, unless possibly one was working in London as an environmental health officer. The normal levels of environmental noise would not usually induce hearing loss although there was clearly a social cost involved when people were exposed to noise. On sound insulation, he felt that the aim should be to achieve the best result from the building materials in use but some enforcement authority was needed to ensure that inadequate constructions were not permitted by default.

DISCUSSION - SESSION 7
"OZONE AND CARBON DIOXIDE"

Speakers: Dr. G.J. Jenkins and Dr. A.R.W. Marsh

MR. S. READ (Enviro Technology Services Ltd), opening the discussion, commended the way in which the speakers had put across descriptions of very complicated chemical reactions and atmospheric processes in such an accessible manner.

He thought that the real challenge posed by Dr. Jenkins' presentation was what could be done to reduce levels of trace gases in the atmosphere. These trace gases were products of everyday living, and their control, in order to arrest the Greenhouse effect, was a matter of urgent concern. Another crucial point was which trace gas to target first, and finally, what impact ground level concentrations of ozone have on the upper atmospheric levels of ozone.

Turning to the paper by Dr. Marsh, Mr. Read said that he had found the descriptions of the way in which reactions between the varying amounts of hydrocarbons and NOx could affect the ozone levels near the ground to be of great interest. It was very important to note that reductions in levels of NOx did not necessarily result in a decrease in ozone. He asked Dr. Marsh what the effect of fitting denoxification technology to power stations and other major stationary sources of NOx would be, and secondly, what would be the effect of the forthcoming EEC directive on vehicle emissions.

DR. D.J. BALL (London Scientific Services) said that there was clearly a credibility problem when dealing with pollutants whose effects would not be seen for thirty or forty years. Dr. Ball was certain that politicians found such

timescales difficult. Nevertheless, he considered the pollutants under discussion that afternoon to be extremely important, with potentially major implications for the entire global environment.

Possible effects were changes in climate and changes in sea level, which could affect everyone on earth for generations to come.

Dr. Ball wished to focus his question on CFCs as these appeared to him to be controllable pollutants. Following the initial concern raised about those pollutants, there had been some limitation on emissions of CFCs, but Dr. Jenkins had indicated that levels of emissions were again beginning to rise. In view of the long lifetime of those pollutants in the upper atmosphere - 100 years or so - the fact that they were increasing at a rate of 6% per annum, and that they were a major source of chlorine and big contributors to the projected global warming and ozone depletion, Dr. Ball wondered how much longer the problem would be kicked around in discussions before positive decisions on controls were taken. He wished to question Dr. Jenkins on the decision-making process: specifically, what evidence he felt was still lacking before a decision on controls could be made, how long was the prospective time lapse before a decision could be taken, and what would be the consequences of that delay as determined by current models.

Turning to Dr. Marsh's presentation, Dr. Ball said that reference had been made twice to a windy day in London during which "nothing had happened". Dr. Ball wondered whether that was indeed the case, or whether Dr. Marsh had been referring to a different time scale of reaction; ie the precursor pollutants were still being emitted but secondary pollutant generation was taking place on a much wider area basis, and on a different time scale. Thus, the sources of the primary pollutants might still be important, although the secondary pollutants were not being picked up by the local area survey.

DR. G.J. JENKINS, responding, said that some uses of CFCs were very difficult to replace, especially refrigeration and air conditioning. Clearly, the use of CFCs for

pressurised aerosols for cosmetic purposes was less important, or for foam blowing for hamburger cartons etc. It was those areas that were currently under study in terms of a global convention. Approximately one year previously, the Vienna Convention on Protection of the Ozone Layer had been agreed under the UN Environment Programme. In effect, that had been a general statement of good intentions towards the ozone layer, but lacking any teeth. However, currently under negotiation was a protocol on limiting emissions of CFCs and Dr. Jenkins anticipated that within a year or so there would be agreement among the major producers of CFCs on how to control them. At present, there was a polarisation of views between the Europeans on the one hand, who wished to see a ceiling imposed on the overall production of CFCs, and the Americans, who did not wish to see any such limit but a restriction on their use in various sectors such as aerosols - which would not hurt American producers because they had already developed alternative propellants. However, he anticipated that the outcome of current discussions would be some regulation on the use of CFCs, thus protecting both the ozone layer and the global climate.

As to how long it was possible to delay action without making matters worse, Dr. Jenkins referred to future monitoring plans, another outcome of the current negotiations on protection of the ozone layer. The intention was not only to monitor total ozone, but also the profile of ozone, so that changes at 40 km height (where changes are expected first) in the stratosphere could be detected. Such a monitoring strategy under the protocol, should it be agreed, would also look at the chlorine compounds which were expected to cause the depletion in ozone. Were such an early detection network to be set up, any specific control decision could be modified according to the early warning results obtained.

Turning to methane, Dr. Jenkins said that the reasons for a rise in methane levels were still unclear. It could be due to increased emissions from agriculture, which would be very difficult to control since the problem was largely associated with the developing nations, rice paddys, etc. If the cause turned out to be carbon monoxide, then controls applied to combustion sources of carbon monoxide might decrease the

methane problem. However, until the atmospheric chemistry was thoroughly understood, no real decisions on controls could be taken. Far more research in that area was needed.

As to the question of CO_2 increases, the problem was that most of it was generated by the combustion of fossil fuels in the developed countries. There were three control options. First, serious encouragement of energy conservation measures. Secondly, through a closer study of the socio-economic impact of climatic changes, some compensatory benefits might become apparent to offset the negative effect of global warming in specific areas. This was the so-called "stick it out" theory. It might be possible to accommodate climatic change as long as it did not happen too quickly. Again, many studies and assessments were necessary before the validity of that option could be satisfactorily determined. The third option was to reduce the amount of CO_2 emitted from combustion, especially power stations, by switching to alternative nuclear powered generation of electricity, since nuclear fission emitted no CO_2. Indeed, a rapid expansion in nuclear power could have a very significant effect on the CO_2 problem. While, since Chernobyl, that was not a popular policy to adopt, it had to be considered.

In brief, then, those were the options for control of the main trace gases. The first target was the CFC compounds.

Turning to the specific question about the consequences of delay in action, Dr. Jenkins produced a slide which showed the results of modelled projected ozone depletions due to CFCs, looking at the impact of a halt on emissions of CFCs. The model showed that there would be a recovery, fairly gradual but nevertheless real, in the ozone layer. There was real confidence that restrictions on CFCs would produce a benefit in terms of increases in ozone. If, instead of a complete cessation in CFC emissions, there was a 50% cut, the recovery would be much slower.

DR. A.R.W. MARSH, responding to the four questions raised by Steve Read and David Ball, turned first to the impact of ground level generation of ozone on stratospheric levels of ozone. Given that the bulk of ozone was in the

stratosphere, there was still some debate about what was the major source of ozone in the troposphere, particularly over Europe as a whole. As he had demonstrated, on occasions the Rotterdam plume could be observed in Southern England. In anticyclonic, high pressure area conditions over the whole of Europe there were noticeable and very large areas of enhanced ozone. It remained to be proven exactly what contribution these made to the general levels of ozone in the lower levels of the atmosphere. They were certainly significant in a regional sense. There was a proposal to establish remote site sensing stations around Europe to monitor ozone, with a view to answering exactly that question. Educated estimates of the levels of stratospheric ozone in the lower troposphere were in the order of .02 ppm or 20 parts per billion. The values observed on a photochemical day were of course five times that level, or even higher. Thus, there was no doubt that on a local scale, photochemical oxidant contributed very substantially indeed, being the dominant factor. However, on a total volume area basis the balance of the sum was unclear.

Turning to the question about fitting NOx controls to power stations etc, Dr. Marsh said that power stations were designed to be efficient users of fuel and that the hydrocarbons emission from that source was relatively very small, although power stations were significant sources of NOx. The net result was that enhanced ozone production in the plume did not occur until the plume mixed with pollution from urban areas, which contained the necessary hydrocarbons to fuel the ozone production processes. While generation of ozone in a power station plume was possible, his observations had shown that it was a very rare event in the UK and generally a power station plume would be associated with an ozone hole or trough, rather than an elevated level of ozone in the atmosphere. That phenomenon had been observed as much as 600 kilometres away from the source on occasion.

As to control strategies for vehicle emissions, the main question in relation to control strategies was where exactly should the controls be taking effect. Most systems had a trade off of benefits eg, initially low ozone could result ultimately in increased nitric acid formation. The whole question was very involved and required the use of good

computer models in order to answer specific questions in relation to control strategies.

Finally, turning to Dr. Ball's question about what exactly was happening on the windy day in London, Dr. Marsh agreed that because of advection the ozone formation was occurring over a wider area and longer time scale and that the snapshot picture represented on his slide had not told the whole story. The matter was not straightforward - ie the integral of formation over time was not necessarily constant. Very windy days were usually associated with a deep mixing layer which meant that precurser concentrations fell rapidly so that the reactivity regime was rather different. This could be expressed as the number of molecules of ozone formed per hydrocarbon type and computer models were capable of expressing that state given sufficient data about time of day, meteorological conditions etc.

DR. M. F. FOX (Chairman of Session, and from Leicester Polytechnic's Pollution Control Project) wished to question Dr. Jenkins further on the use of CFCs. He agreed that some of the current CFC applications might be regarded as non essential and trivial uses of a complex chemical with the potential for causing widespread environmental disruption. However, he considered that the history of air pollution control had shown that prohibition of the use of a particular substance did not work well: people would find a way to circumvent the ban. Thus, it was necessary to offer an alternative technology. As he understood it, at the cheaper end of the market CFCs had been replaced by compressed propane or butane which apparently substituted a long term hazard for an immediate short term hazard. He suggested that a woman smoking while putting lacquer on her hair might be enveloped in a six foot flame. He wondered, therefore, what alternative to these alternatives was being suggested to replace CFCs in the non-refrigeration aspects of their use.

DR. JENKINS said that the use most widely recognised as a non-essential CFC use was in aerosol propellants for cosmetic sprays. Obviously there were many uses for aerosol cans, some of which were for essential, eg medical, purposes. In the United States CFCs in cosmetic applications have

been replaced by hydrocarbons. These had been shown to be slightly more dangerous in safety terms and there had been a few accidents in the home and in the factory. One solution might be to decide that we do not need propellant aerosols as much as we thought: we managed perfectly well without them for centuries. It was perhaps a question of educating people to use alternative products on their bodies ie the same substance in a different form. There were many alternatives already available in the shops, some of which were actually more efficient than aerosols.

As to styrofoam blowing, substitutes were more difficult. A lot of work was being done although he was not sure what progress has been made.

A lot of companies were putting a great deal of money into research into alternative refrigerants. Du Pont in the USA had found a much more expensive alternative; however, since the actual value of the refrigerant in relation to the overall plant was quite small, even if the refrigerant cost ten times as much as formerly, the overall price of the consumer product would not be significantly raised.

However, it should be remembered that CFCs had served useful purposes in the past. For example the Southern States of the United States would not have developed so well had it not been for refrigeration and air conditioning based on the use of CFCs.

MR. I.W. BARKER (Chairman NSCA) had a question on the time scales in relation to CO_2 build-up and the Greenhouse effect. He referred to the presentation eight weeks earlier at the 7th World Clean Air Congress in Sydney by Dr. Tucker, Head of Air Pollution Research at the Commonwealth Institute of Environmental Research. The theme of his keynote address had been trace gases in the atmosphere. He had made the point that the hitherto accepted time scale over which a doubling of global ambient concentrations of CO_2, to reach the trigger concentration of 600 parts per million (ppm) could occur was around the middle to the end of the 23rd century. The 600 ppm concentration was anticipated to produce a 3 - 6 degree C increase in temperature in the Northern Hemisphere and perhaps a 1 - 2 degree C increase in temperatures in the

Southern Hemisphere. However, Dr. Tucker's view was that the time scale was far shorter than that; he predicted that the 600 ppm trigger point would be reached in 35 years' time.

Mr. Barker said that he had later read an account of a Seminar held in Washington DC, also on CO_2 and the Greenhouse Effect. This event had been sponsored jointly by the US EPA and UNEP. After 5 days' deliberations, there appeared to be general agreement that the time scale over which the 600 ppm trigger concentrations would occur was actually 14 years from now. Thus, the dire consequences of the increase in CO_2, the increase in world temperatures and the impact of world climates appeared to be much closer than had hitherto been predicted. He asked for Dr. Jenkins' comments.

DR. JENKINS said that most projections agreed that a doubling of CO_2 levels in the atmosphere, to the 600 ppm trigger concentration, would occur by about 2070, ie in about 100 years' time. In the past few years it had been realised that other gases including methane and CFCs would add to the build up of CO_2, so that by about 2030 while CO_2 itself would not have doubled all the other gases would have contributed to the same extent producing an effective doubling of CO_2 in the radiative sense: effective transmission of the atmosphere in the infra red would have changed by an equivalent amount to a doubling of CO_2. Dr. Jenkins considered that most people would accept the date of about 2030.

However, the critical date also depended on future projections of the rate of growth in the emissions of various trace gases. All such projections were subject to great uncertainty. CO_2 levels were projected from factors such as industrial growth and population change; no one knew quite why methane levels were rising at present, let alone what their future growth rate would be, similarly with N_2O, and levels of CFCs depended entirely on how much were used. If further limits on the use and production of CFCs were imposed, then the projected temperature increase associated with current projections would not occur.

In summary, if gases continued to increase at about the same rate as at present, then a projected global warming of 3 degrees C, plus or minus 2 degrees C, would be expected to occur by the year 2030. There might be some delay, in the order of one or two decades, due to the effect of the oceans (the ocean temperatures would take some time to catch up with the forcing temperatures of the atmosphere), but the <u>commitment</u> to the overall global rise in temperature would occur by the year 2030. However, there were areas of great uncertainty including feedback processes through clouds which were very poorly understood at present. Global heating would cause more water vapour to be put into the air, and that might affect the amount and average height of clouds in the atmosphere. Only a very small change in total cloud cover - a few percent - would have the effect of negating the Greenhouse effect almost completely. It was because of the great uncertainties that he stressed the need for more research in order to feed greater understanding into the decision-making process.

As to the projected 14 year time scale for a doubling of CO_2 referred to by Mr. Barker, Dr. Jenkins could not understand that conclusion at all, nor did he believe that it was tenable.

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FUTURE EEC INITIATIVES

— By —

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FUTURE EEC AIR POLLUTION CONTROL INITIATIVES

by
Stanley Clinton Davis

This is the second occasion in recent months when I have had the opportunity to address a conference organised by the National Society for Clean Air. The last time was just over a month ago in London, when I shared a platform with, among others, the Minister, William Waldegrave, Lord Marshall, Chairman of the Central Electricity Generating Board, and Beate Weber, as Chairman of the European Parliament's Environment Committee. The subject was the challenge of acid rain, and at that time, the United Kingdom Government had only just announced the authorisation which it had given to the Central Electricity Generating Board, to retrofit the equivalent of three 2000 MW coal-fired power stations over the next twelve years.

That announcement marked a remarkable departure from the string of denials which had hitherto characterised the United Kingdom response to the charge that it was the single largest contributor to the ecological disaster confronting our neighbours in Scandinavia, as well as others within the Community. Of course, these assertions or opinions were expressed repetitively by the CEGB and others. While repetition of a view is no guarantee of its correctness, that was the position adopted in the United Kingdom for too long. It was always said that somehow or other more research has to be done before the case for action could be made to the satisfion of the UK Government. The overwhelming majority of scientists meeting in Karlsruhe in 1983 came to the conclusion that there was a causal link. Scientists in Scandinavia, as you may have seen from a programme the other day on acid rain, were asserting many years before that, that there was a causal link. But denials continued to emanate from the United Kingdom, and to my own personal knowledge from the CEGB; the denials went on and on until just a few weeks ago, when a causal link was finally acknowledged.

Well, at least total denial is out of the way, and on the 19th September at the NSCA/IEEP conference, I was able to welcome the decision to retrofit 6000 MW of power station capacity as a first, but only as a first step. I formed, however, the strong impression that so far as the UK Government and CEGB were concerned, they did not really want to go any further until much more research was done and they were not impressed by the fact that the German Government has authorised an immensely more costly programme than the one that has been suggested by the European Community as appropriate for this country.

The question really remains as to whether the pressure from within and without the United Kingdom will convince the Goverment that much more needs to be done to clean the sulphur dioxide as well as the dust out of industrial smoke. Of course, I appreciate very well that further industrial decline could contribute to a reduction of atmospheric pollution. That has already happened and I hope nobody will believe that it offers the route to salvation. You may know that certain figures were submitted to the Commission the other day in support of applications for regional aid funding, which suggested that unemployment was going to continue at a far higher level than was being acknowledged within the United Kingdom. I hope, anyway, in this context that we find that the solution does not lie in further constriction of economic growth, but in the ability to do something about atmospheric pollution when our industries are back at work; that is the real test.

Today I want to widen the debate to talk about air pollution in general, to examine the reasons for European Community involvement in the prevention of atmospheric pollution and to look at the actions being taken at Community level to try to resolve the problems. Of all the environmental issues, pollution of the air has to be tackled on an international scale. If Chernobyl has taught us anything, it is surely that. We know that the atmosphere transports many air pollutants hundreds of miles before returning them to the earth's surface. Gaseous sulphur, for example, can remain suspended in the atmosphere for weeks before being deposited; indeed, some part of the sulphur deposited in Europe originates in North America. For this reason the exchange of air

pollution between nations can be enormous both in scale and complexity. The situation between the Federal Republic of Germany and France provides, I think, a good example. The Federal Republic estimates that it is responsible for 124,000 metric tonnes of sulphur deposited in France each year and France does her best to reciprocate by sending an estimated 167,000 metric tonnes across the border, where it contributes to a grand total of 760,000 tonnes dumped annually on the Federal Republic. This exchange demonstrates the complexity of pollution patterns. Even though the prevailing winds in Europe are generally in a north-easterly direction, the France/FRG exchange demonstrates that in practice the situation is far more complex. Therefore, it is clear that any serious attempt to reduce air pollution damage over a broad region, like Western Europe and Scandinavia will require concerted and effective multi-national action. I believe this to be a political imperative and that is the theme which dominates the work of the Commission.

The Organisation for Economic Co-operation and Development, OECD, and the United Nations Commission for Europe, ECE, have done a great deal to bring about international consensus on the need to control emissions, particularly of sulphur and nitrogen. But the European Community is unique in its ability to impose binding directives on its member states once these, of course, have been agreed by the Council of Ministers. Remember, we are now talking, after the accession of Spain and Portugal, of a community of twelve countries with a total population of nearly 320 million people. So, accepting that there is an overwhelming case for action at Community level to combat noxious air pollution, the question arises, what is the Community doing about it?

Well, action on the part of the Community has been taken on three fronts. First, setting ambient air quality standards, second, setting product standards and third, reducing emissions. On air quality standards, Community directives have been adopted setting limit values and guide values for sulphur dioxide and suspended particulates, for lead and for nitrogen dioxide. But I am bound to say here, that implementation of these directives by governments has been far from satisfactory. Thus, for example, the sulphur dioxide directive was adopted in 1980 and should have been

implemented by July 1982 but two of the member states, Ireland and Greece, have not yet introduced implementing measures for this directive. The Commission has therefore started legal proceedings against them. So far as the other eight members are concerned, excluding Spain and Portugal, who for the time being are still enjoying a honeymoon period because they must be given time to implement Community directives, the Commission is not satisfied that the implementing measures of the eight are complete and accordingly we have told them in no uncertain terms, that unless they take appropriate measures, they will be brought before the European Court. That, indeed, is our duty. So you see we still have a long way to go before we can talk about Community achievements in the field of quality standards.

As far as product standards are concerned, the most significant Community measures in the field of air pollution are represented by the directive on the sulphur content of gas oil, where the Commission has now proposed an amendment aimed at reducing sulphur levels even further, and by the directive on lead in petrol, which of course has as one of its most important requirements, that by 1st October 1989 at the latest, national governments have to ensure a balanced distribution of lead-free petrol throughout their territory. However, it is in the fixing of standards for emissions to the air that the Community has recently had the most difficulty in arriving at a common position. Community standards of course do exist, for example in relation to gaseous emissions for motor vehicle exhausts comprehensive requirements have been laid down in a directive fixing limits for emissions of carbon monoxide, hydrocarbons and nitrogen oxides and this directive, which goes right back to 1970, has already undergone four considerable modifications to tighten up controls progressively. However, the fifth amendment, proposed by the Commission at the beginning of 1985, has not yet been formally adopted by the Council, although there was a near agreement reached at Luxembourg in June 1985 and I, and successive Presidents in office of the Environment Council, have used every argument in the book to try and get this near agreement into full accord.

Concerning emissions from industrial installations, there is a

Community directive adopted in 1984 and due to be implemented by June 1987, providing that member states must make the operation of stationary industrial plants subject to prior authorisation. This authorisation will be issued only when the competent authority has established, among other things, that all preventive measures, including the use of the best available technology, have been taken and that the operation of the plant will not generate any air pollution harmful enough to endanger human health or damage biological resources and ecosystems. The industrial plants concerned are those in the energy industry, metal working, processing of non-metallic mineral products, waste disposal and certain chemical industries. For existing plants, member states will apply policies and strategies aimed at their gradual application to the best available technologies. The directive established a working framework for particular cases and the Commission's proposal for reducing emissions from large combustion installations was a first application of this approach.

The proposal seeks to reduce emissions of sulphur dioxide by 60% and oxides of nitrogen and dust by 40% from combustion plants with a rate in thermal output greater than 50 MW over a period between 1980 and 1995. It also provides for the establishment of strict emission standards for new plant and these standards should reduce the quantity of sulphur emitted by 85%. That is the background against which present progress within the Community concerning air pollution has got to be judged.

So far as the European Commission is concerned, our two top priorities are first, to secure the agreement by the Council of Ministers to our proposals for very substantial reductions on emissions from large combustion installations and second, to achieve the final adoption and implementation of the near agreement reached at Luxembourg last year on new European Community standards for emissions from motor vehicles. That near agreement (because there was initially only one reservation from Denmark and later on a further reservation from Greece) provides for different values for vehicles of different capacities, so that, as far as possible, Community requirements can be complied with at reasonable cost and using the appropriate technology. The Commission believes that the environmental impact of these standards

will be equivalent to that of current US standards.

As most of you will know, adoption of these Community standards is being delayed by two quite different factors. I have already spoken of the reservations of the two countries concerned. Denmark tends to side with its Scandinavian neighbours and, partly for environmental and partly for internal political reasons, is holding out for the adoption of the so-called US 83 standards with their accompanying requirements for the use of catalytic convertors. The position of Greece is quite different; Greece is hoping to negotiate a Community contribution towards the cost of clearly a much-needed clean-up programme for the Athens air in return for its agreement to the vehicle emissions directive.

I should add in parenthesis here, reflecting for a moment on the difficulty of those negotiations, that we received a great deal of special pleading from vested interests, perhaps a fact of life that is not unknown to most of you here. The car industry, particularly of course in the United Kingdom, France and Italy, were hostile to the Commission's proposals for a long period - they argued that the reductions could not be achieved without a great deal of expense, and that the results could not ensure that there would be any marked improvement. One or two days before we reached that near agreement, which included the United Kingdom and France and Italy, one particular motor car manufacturer in Europe wrote to me and said we really must not go down this route, articulating once again the arguments to which I refer. And one day later the self-same chairman of this car manufacturing company wrote to me and said, "Congratulations on the near agreement and we must ensure that it becomes a full agreement as soon as possible, so that investment patterns in the industry can be made very clear". That is the sort of thing that you have to put up with, as a Minister, as councillors, as officials and no less as a Commissioner.

But despite the difficulties to which I have alluded, I do believe that in the end good sense and common sense will prevail, because it simply cannot be denied that full implementation of the new European Community standards for the whole car fleet on the road will result in about the year 2000 in a major environmental improvement, a reduction

of hydrocarbon and nitrogen oxides emissions from this source of something like 50%. But even in this situation there will be one major cause for regret, that the framework of regulations in Europe for motor vehicle emissions, which hitherto has been a unified one based on the work of the Economic Commission at Geneva, has now become fragmented, reflecting the difference of attitude in the EFTA countries and the ones in the Community.

It is of course clear that that situation is very unsatisfactory, even if, as I believe, the car manufacturing companies will continue with an investment programme as if the near agreement was a full concluded agreement. But it will create problems for the industry and I doubt whether that is satisfactory, even in environmental terms. We cannot, however, change that situation today. What I am convinced of is that Europe needs a regular framework within which environmental, energy, safety, industrial and commercial considerations are all taken into account and I also believe that progress on this front would contribute significantly to the work on nitrogen oxides under the Geneva Convention on Long Range Transboundary Air Pollution.

A few words now about large combustion installations and the progress, or perhaps lack of it, in that field. In fairness it would be right to say that there has been some halting progress. Of course, there are large problems here. There are wide differences between Community member states as to the damage experienced - in the United Kingdom it is claimed that the damage is barely noticeable, although I am not sure whether that is correct. Indeed, contrary evidence seems to be building up. But in Germany there is enormous forest die-back and it's not just a question of beautifying the countryside with trees. Tree in Germany are a part of the culture, and part of the economy. The industry employs thousands of people and what is more trees protect us.

We must understand and be sympathetic to the problems that exist in Germany if we are going to apply a Community spirit to these matters, otherwise what is the value of being in a community if this fellow-feeling just goes out of the window? In the same way, I find it somewhat dispiriting that for a very long time the Germans who wanted us to

recognise the problems of their dying forests were unwilling to recognise that the problems of forest fires in the south of Europe were costing lives and doing immense damage to the economies of those countries and that inaction in that regard was not representative of true Community spirit either. I am now told that some progress is being made in that field too. So there are these wide differences, as there are also about available fuels, economic factors, the contribution of emissions to transfrontier pollution and so on.

Up to March of this year, I could not help being reminded, in relation to the determination of Ministers, of something that the late Aneurin Bevan once said about the faltering military campaign in Italy during the war. He said the allies confront this issue like an old man approaching a young bride, fascinated, sluggish and apprehensive and that was, I think, a fair reflection of the attitude of Ministers to this particular issue. But in March there was a change for the better, in that an almost unanimous agreement was reached on a framework within which agreement would be sought by the end of this year. I regret to say that the United Kingdom was unable to join this agreement.

The shape of this framework was as follows. First, the regulation of emissions from all new plants on the basis of standards relating to best available technology, not involving excessive costs. Second, a two-stage approach for overall reductions in emissions. Third, the setting-up of a Community target for an overall substantial reduction in sulphur dioxide emissions: an improvement on the reduction envisaged by the Helsinki Protocol. Fourth, the setting-up of appropriate programmes, member state by member state. These programmes would take account of the scale of the emissions from different member states, their contributions to overall pollution in Europe and the special situations related to their stage of economic development, the nature of locally available fuels and the overall efforts involved as well as other relevant criteria. Lastly, there would comparable action in relation to emissions of nitrogen oxides.

Following this agreement, the Dutch Presidency of the Council of Ministers worked very hard on a paper designed to fill in the details. It was put to the Environment Council

in June but I have to say that I was obliged to express my disagreement with the result. In fact, in order to reach a compromise, a proposal had been advanced, which in my judgement would have been little more than cosmetic, and which would not provide an adequate solution to the problem of acid rain. In particular, I took exception to the dates of the two stages, which were 1985 to 1995, 1995 to 2000. I took exception to the overall national reductions in sulphur dioxide required by the end of the first stage, a minimum of 28% for all member states, and I took exception to the fact that the national reductions for the end of the second stage were to be left to later agreement. I did that because one has to remember that the Commission's proposal, which has been on the Council's table since the end of 1983, having been introduced by my predecessor, Karl Heinz Narjes, envisages an overall 60% reduction in sulphur dioxide emissions from all large plants over 50 MW over the period 1980 to 1995, with 40% for nitrogen oxides and dust.

In view of the delay in the Council, I have to concede that there certainly can be some discussion on the timing of the reduction. There is also room for maneouvre in those countries which are acknowledged to have special problems, for example Portugal, Spain and Ireland, and which, at the same time, do not make large contributions to the overall levels of acid deposition. But I took the view at that time, and I still do, that the Presidency compromise went too far away from the Commission's original proposals and, indeed, would have produced little or no environmental benefit over and above what was already envisaged by a number of Community countries. I do not believe that we should go in for shams. I do not believe that camouflage is the right way to treat or to try to treat this particular problem. So we still have a great deal of work to do before we can envisage a solution to the problem of the contribution of large plants to air pollution. Let us note well that time is not on our side, that the damage being caused to our priceless heritage within the Community and elsewhere goes on remorselessly and, for the most part, irredeemably, and the cost of neglect in terms of corrosion and environmental destruction in the EEC alone is vast, perhaps in the order of #33,000 million a year. That is the scale of the problem.

As a final reflection I would emphasise that environment

policy is intended for the protection of man and for the improvement of his quality of life. That brings me to the European Year of the Environment. This year was designated by the European Council and our view, on behalf of the Commission, is very clear. We say that this year must be seen as a major opportunity to raise the awareness of the importance of environmental issues and to change attitudes. The year, which will run officially for twelve months starting on the first day of spring 1987, unlike other years, however, has to go on and on and on. It is designed, after all, to make environmental protection an essential component of the economic, industrial, agricultural and social policies of the Community, as well as the transport policies for which I am also responsible. It has got to operate, of course, within the member states, and within all of them. There must be no shirkers. It is designed to stress that the protection of the environment must be seen as being complementary to economic growth and to job creation. It is designed to make our citizens aware of what is at stake and how much is threatened and also how a healthier and more attractive environment is able to contribute to our health and well-being and to an improved quality of life for all of us. It is designed to reach out for the active and positive support of goverments and parliaments but, equally important, of companies and associations, of local authorities, trade unions and many other voluntary oganisations and above all to the individual citizen, whatever his or her age. We shall be looking to the universities and to the schools because it is something that embraces all our needs.

In this context the challenge of air pollution has a singular importance. Over-worked lungs, poisoned lakes, crumbling buildings, dying forests are all facts of life and it is high time that all politicians learnt the facts of life. It follows, therefore, that an agreement on an enduring response to this challenge, which is essential to the well-being of all of us, and of generations to come, would be a fitting and appropriate and indeed wonderful start to the European Year of the Environment.

Mr. Chairman, Ladies and Gentlemen, I have taken a great deal of your time, but whenever I start to talk about environmental issues within the Community, I fear I tend to get a little carried away, because it is so important and I

know and am confident that not only do you share that point of view in the work that you undertake in the National Society for Clean Air but that you will play a major part in alerting the public to what is at stake and making these matters essential to the policies of this particular country at the very least.

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SMALL SCALE COMBINED HEAT AND POWER THE TECHNOLOGY AND IT'S APPLICATIONS

– By –
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SMALL SCALE CHP
THE TECHNOLOGY AND ITS APPLICATIONS

by
R.W. Grey

INTRODUCTION

The Energy Technology Support Unit at Harwell works for the Energy Efficiency Office of the Department of Energy. Its job is to manage a programme of research, development and demonstration projects to promote the more efficient use of energy throughout industry and all types of buildings in an attempt to achieve very substantial energy and energy cost savings. Hence the slogan "Get more for your monergy" in this, the Energy Efficiency Year. The author's role within ETSU is to manage a programme of demonstration projects specifically demonstrating the use of small scale or, as they are sometimes referred to, micro CHP systems.

This paper describes in general terms what micro CHP is, explaining some of the differences between this and the large scale city wide CHP DH schemes that Mr. Atkins' paper describes. It also illustrates how micro CHP systems save money for the user and energy for the nation and then briefly describes some of the applications for which the technology is suitable.

GENERATING ELECTRICITY

Whenever electricity is generated, either in a power station or a mobile generating set, only about 35 per cent of the energy input is converted to electricity. The rest is usually waste heat in the form of cooling water at about 30 to 35 degrees centigrade, which cannot therefore be used for space and water heating in buildings. It is however possible to design generating systems so that some of the reject heat can be recovered for practical use in industrial processes or

in heating buildings. Then, typically, the efficiency of the system is of the order of 80 per cent, although it is possible in some circumstances to achieve efficiencies of converting the input energy to useful heat and power of over 90 per cent.

SMALL-SCALE CHP

CHP is definitely not a new idea, but small-scale CHP is relatively new. The larger systems have been used for many years in the iron and steel and paper making industries, in district heating schemes on the Continent and in one or two places in the UK. But while a power station produces many hundreds of megawatts of electricity, a typical industrial system might be just a 3.5 MW gas turbine; such as the one installed at Smith, Stone & Knight's paper mill in Birmingham, a demonstration project funded by the Energy Efficiency Office (reference 1). This project won a 1986 Regional Gas Energy Management Award. The gas turbine is housed in an acoustic enclosure and exhaust gases are fed through into a waste heat boiler. The physical size of such systems and the associated controls is very much less than the size of a CEGB power station. However, compared to small-scale or micro CHP systems, they are still relatively large.

Most micro CHP systems are actually small enough to fit into an existing boiler house. These small-scale systems are based not on steam and gas turbines like the larger systems but on spark ignition internal combustion engines and they produce between about 15 and 250 kW of electricity.

It is normal practice when referring to the size of units to quote just their electrical output. The thermal output is generally one and a half to two and a half times the electrical output. There are currently three companies in the UK marketing systems of this size - Applied Energy Systems, based in Watford, Holec, based in Leatherhead and WaterMota based in Newton Abbot. (Reference 2). One or two other generator set manufacturers are also beginning to enter the micro CHP market eg Shannon Power Services in Bury and Dawson-Keith in Havant.

MICRO CHP COMPONENTS

The main components of one of these units are: an engine; a generator; a heat recovery system; a set of controls; and sometimes an acoustic enclosure.

THE ENGINE

The engines of these units are either automotive based or industrial spark ignition engines adapted to run on either one of several different fuels, normally natural gas. They can also run on bio-gas, LPG and diesel.

The automotive engines have a relatively short life compared to a normal boiler and engines can need replacing every 10,000 to 40,000 hours (every 2 to 6 years) depending on use. However, it should be noted that the full cost of engine replacement is included in the maintenance contracts offered by the suppliers and also in the economic assessment done by consultants or suppliers when assessing the economic benefits of a unit at a particular site.

The industrial engines, however, are more robust, have a longer life and can work for 20 years or more without needing replacement. As yet there is insufficient evidence to suggest which type of engine is best for a particular application but the Energy Efficiency Office's demonstration projects involve both sorts of engine.

THE GENERATOR

The generators of these units produce three-phase alternating current at 415 volts. There are two principal types: mains-excited generators and self-excited generators. The mains-excited type need electricity from the mains both to start the engine and to allow the engine to continue to run. In other words, if the grid fails the CHP unit will also stop. This type is slightly cheaper than the self-excited version, which starts off batteries and can therefore work independently of the grid thus providing the ability to act as a stand-by generator. The self-excited version is more complex and therefore slightly more expensive.

However, when considering these units the individual components should not be treated separately in an assessment of the capital cost. The purchase is of the entire package and when examining the alternatives available from the suppliers the main point to be considered is whether or not the CHP set is going to act as a stand-by generator to an existing power source. In either case it is necessary to look at the available units and compare like with like. Experience has shown that it is important, when assessing the economic benefits of using these systems, to attempt to evaluate the cost of supplying a separate and independent stand-by generator facility. That cost can then be deducted from the capital cost of the CHP unit if the decision is to allow the CHP unit also to act as a stand-by generator.

HEAT RECOVERY

The heat recovered from CHP units generally comes from the engine cooling water, the exhaust gases, the lubricating oil, and in some cases from the air within the acoustic enclosure. If additional heat exchangers are employed it is also possible to recover some of the latent heat in the exhaust gases and thereby reach efficiencies of 90% and above. The total amount of heat recovered ranges between roughly 40 and 500 kW, depending on the size of the unit.

CONTROLS

Control panels for micro CHP units are supplied as an integral part of the entire package. The controls have to ensure that the unit operates safely, legally, reliably and efficiently. The unit must obviously run safely within its own temperature, pressure and emission limits. It must satisfy the requirements of the Electricity Council laid down in Regulations if it is going to be operated in parallel with the grid, and these requirements ensure that the unit does not adversely affect the quality of the power being supplied by the grid to other users and, more important, that anyone working on the grid is not injured by a CHP unit still running when the grid is switched off for maintenance.

The user of a CHP system is obviously interested in the control of the unit to satisfy the various heat and electrical requirements in a building most efficiently. It is normal to activate or control a micro CHP unit on the heat demand of a site, with the electricity generated being fed in to the consumer circuits and any excess flowing back into the grid. In other words the unit is controlled very much like an additional boiler, although economics dictate that it has to be used as the lead boiler. In contrast, it is possible to control some units by following the variation in the electrical demand of a site but this is more unusual than following the heat demand.

ACOUSTIC ENCLOSURES

The last major component is the acoustic enclosure. This is optional, as noise levels from these units are comparable to those from much of the existing plant found in boiler rooms. Costs for an enclosure are roughly £1,000 to £2,000, depending on the size of the unit. Units without enclosures make maintenance easier but no protection is then afforded to the personnel in the boilerhouse. If a unit is going to be installed externally then an enclosure may be needed for weather protection.

INTEGRATION WITH EXISTING SERVICES

It is important to ensure that the heat load a unit is intended to supply is the **"base"** heating load, which should be big enough to keep the unit working for at least 4,000 hours per year. The longer the unit can run, the greater the savings to be achieved. The electrical load to be supplied by the CHP unit should exist for roughly 12 hours per day and should generally be greater than the output of the unit.

Installation costs will be reduced if there is a suitable site available on which to install a unit eg space in an existing boiler house. It will also reduce costs if the various gas, electricity and heating services are not too remote from the proposed site for the unit and the existing building controls are able to cater for the addition of the unit. But both electrically and on the heating side, installation of micro

CHP units is relatively straightforward, such that a competent M & E contractor should be able to install a unit correctly without any difficulty if he follows the supplier's instructions.

In terms of electrical output, there are three principal ways to operate a unit. First, there is the stand-by mode of operation. This is where the unit meets all or part of the load on site if the grid fails. Second, is the stand-alone mode (sometimes called island operation), where a unit is installed to meet either part or all of the load from the site, isolated from the grid. The third and perhaps the most common form, is parallel operation, where the unit meets all or part of the load of a site and is supplemented with electricity from the grid according to demand. The electrical installation will undoubtedly be more complicated than wiring up an ordinary boiler but even when run in parallel with the grid and acting as a stand-by generator, the electrical installation of a CHP unit should not be anything that a competent electrical contractor could not handle.

TYPICAL SAVINGS

Experience from the Energy Efficiency Office's demonstration projects suggests that nett savings of 2p for every kW h generated by CHP units are achievable. However it should be stressed that these systems do not actually reduce a building's energy demands; they simply give a reduced energy supply cost. Other benefits associated with these systems are that maximum demand charges can be reduced by generating power privately. Savings can also be achieved by exporting electricity to the grid and by having a stand-by generation facility that can help to avoid production losses or inconvenience in the event of a mains failure. Current experience suggests that these systems can achieve simple pay-backs in the order of two and a half to five years but this depends largely on the number of hours the unit runs.

The capital cost of a micro CHP system is currently about £400–£500 per kW of electrical generating capacity installed. Thus a 200 kW unit would cost £100,000 to install, a 15 kW unit only £7,500. It is not therefore unreasonable to consider the investment associated with these systems on the

basis of simple pay-back. However the much higher levels of investment assiociated with the much larger CHP DH systems should not perhaps be presented in simple pay-back terms.

RESIDENTIAL APPLICATIONS

Residential applications suitable for micro CHP include hotels, hospitals, universities and colleges, boarding schools, sheltered housing, old people's homes, prisons and detention centres.

Many hotels have heat and electrical demands for up to 18 hours a day. Both these loads are fairly constant throughout the year and in fact the hotel sector now has the largest number of micro CHP installations in the UK with more than 50 sites in all having installed these units. Furthermore, many of these sites have more than one unit for it is often possible and economical to install more than one unit at a particular site.

At the Castle Hotel in Windsor (a Trusthouse Forte Hotel), six 15 kW Fiat TOTEM units were installed in 1983 and detailed monitoring of this system as an EEO demonstration project ended in September 1986. The EEO has published an interim report on the second year's monitoring (reference 3) which is available from ETSU, free of charge. The final report on the second year's monitoring should be available early in 1987. This system has not performed as well as originally expected; but one of the reasons that the Government gives demonstration scheme grants to people installing novel technology is to offset the risk of a system not operating exactly according to specification. The failures are all documented in the two reports mentioned above, the purpose of which is to disseminate knowledge. For, just as the CHPA is in the business of disseminating knowledge about CHP, so ETSU and the EEO is in the business of disseminating knowledge about how the small-scale CHP systems in the demonstration scheme perform in practice, so that potential users can be informed about how the initial systems have gone wrong and how such problems can be avoided in the future. Indeed the EEO is planning to produce a set of guidelines for publication in

1987 on how these systems should be installed, maintained and operated to achieve maximum efficiency and maximum reliability. It is the author's belief that there is nothing fundamentally wrong with the principles associated with CHP. Many of the problems mentioned above are teething problems with a new technology that can be, and in most cases have been, fairly easily resolved.

Another demonstration site, Hotel Leofric in Coventry, is a 90-bedroom hotel where a Holec 75 kW unit was installed and commissioned in January 1986. Details of this project are available from ETSU (reference 4).

Moving on to hospitals, again the basic water heating requirements in hospitals extend over much of the 24 hours in each day. There are substantial electrical demands over much of the day as well. Hospitals also have a requirement for stand-by generation and are, therefore, ideal candidates for CHP. To date there are about a dozen CHP systems installed in hospitals around the UK and this number is expected to increase rapidly as it is an ideal sector for the application of this technology. The EEO has three micro CHP demonstration projects in hospitals, one of which is at a 450-bed teaching hospital in Bristol where two sets, one of 90 kW and one of 45 kW, have been installed (reference 5).

Another demonstration project is underway at a tower block in the London Borough of Hackney where 136 individual dwellings previously supplied from an oil-fired group heating scheme are now supplied by three 15 kW Fiat Totem units in the basement and here 75% of the electrical output from these units is in fact exported to the local Electricity Board (reference 6).

The University of Keele has installed a 40 kW system to supply a hall of residence housing 340 students and a refectory. The hall is used during the vacation for conferences and so has a year round demand for heating and hot water. The unit was installed and commissioned in October 1985 and is also being monitored as an Energy Efficiency Demonstration Scheme Project (reference 7).

NON-RESIDENTIAL APPLICATIONS

Turning now to non-residential applications, the key sector here is swimming pools and leisure centres, which are absolutely ideal for CHP given their year round heating and electrical demands. The Warrior Square Pool in Southend houses one of the earliest installations of CHP involving two 40 kW units. This has been operating now for several years achieving very good savings. Another similar application is Harrow Leisure Centre in the London Borough of Harrow; this is a very large complex with many different activity rooms, including a large swimming pool and a sports hall. The plant room contains four 40 kW units operating almost continuously, making very good savings. In total, there are now almost 50 leisure centre or swimming pool sites at which CHP systems have been installed.

Another non-residential application for CHP is sewage treatment plants; the sewage treatment industry has for a long time been considered ideal for the application of CHP, principally because of the effectively free fuel in the bio-gas produced by anaerobic digesters. There are about 20 installations of micro CHP units around the UK involving anaerobic digesters and bio-gas fuel. The Water Research Centre is co-ordinating the activities of water authorities in looking at CHP but a large potential for CHP has been identified in this industry and it is believed that over the next five years there will be many more systems going in at this type of application.

CONCLUSIONS

In conclusion, there are now well over 200 separate micro CHP units installed in the UK, between them generating about 4-5 MW of electricity. The Energy Efficiency Office recognises that micro CHP is a good energy-efficient technology with benefits for both the users, in terms of reduced energy bills, and the nation as a whole in terms of reduced energy use. Several demonstration projects funded by the Energy Efficiency Office involving micro CHP systems are now underway and further information on the performance of these systems is available, free of charge, from ETSU.

REFERENCES

1. Energy Efficiency Demonstration Scheme, Project Profile 188, Energy Efficiency Office, September 1986. (Available on request, free of charge, from the Enquiries Bureau, Energy Technology Support Unit, Building 156, AERE, Harwell, Didcot, Oxon. OX11 0RA. Tel: (0235) 834621.

2. Energy Technology Series 4, Small-Scale Combined Heat and Power, Energy Efficiency Office, August 1985.

3. "TOTEM" Total Energy System in a Hotel - A Demonstration at the Castle Hotel, Windsor, for Trusthouse Forte Hotels Ltd. Interim Report ED/70/161, January 1986.

4. Energy Efficiency Demonstration Scheme, Project Profile 243, Energy Efficiency Office, June 1986.

5. Energy Efficiency Demonstration Scheme, Project Profile 227, Energy Efficiency Office, March 1986.

6. Energy Efficiency Demonstration Scheme, Project Profile 219, Energy Efficiency Office, March 1986.

7. Energy Efficiency Demonstration Scheme, Project Profile 228, Energy Efficiency Office, March 1986.

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PUBLIC OPINION ON ENVIRONMENTAL NOISE

– By –
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PUBLIC OPINION ON ENVIRONMENTAL NOISE

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INTRODUCTION

Environmental Health Officers (EHOs) have long standing experience in the investigation and resolution of complaints made by the public concerning disturbance due to environmental noise. Futhermore, annual statistics (FIGURE 1, Ref. 1) are compiled which show the changing trends in the type of noise which people complain about - domestic noise now being by far the most commonly occurring problem.

However, the incidence of complaints is not necessarily the best indicator of the amount of annoyance which people are experiencing due to a particular source of noise: for example people often will NOT complain about something for which there is no apparent or easy remedy - they believe that there is no point in complaining. It is important for EHOs to be aware not only of the incidence of complaints but, more relevantly, which types of noise cause most annoyance and distress.

This paper presents and discusses results of surveys carried out in Europe, the UK, and areas in the North West of England. A call is made for an urgent improvement in noise policies and controls aimed at the removal of existing noise problems and the prevention of new ones.

ATTITUDES TO ENVIRONMENT - EC AND UK

Eurobarometer No. 18 (Ref. 2) included a survey, carried out in October 1982, of some 9719 persons in the then ten member states. It focussed on three important aspects of the state of European opinion on:

(a) the attitude to the local environment (noise, open space, landscape etc.);

(b) the level of concern about pollution issues on the national and the international scale; and

(c) the question of whether an environment policy should be encouraged accepting if necessary higher costs to industry and, possibly, curtailed growth.

Environment

Summarised the results show that about half the Europeans (55%) say they have no reason to complain about their local environment. The remainder indicated the most widespread causes of dissatisfaction (on the **local** scale) as being deterioration of the landscape; noise; and air pollution.

A comparative index of dissatisfaction showed that in the UK the level of concern about **local** environmental matters is slightly below the European average. Also on the **national** scale the UK is apparently less concerned than the average in Europe about matters such as oil damage to beaches, air pollution and river pollution, the UK exception to this generalisation being the above average concern about the disposal of nuclear waste.

Noise

What is clear from this survey is that an estimated 34% of UK residents feel they have reason to complain about noise; the corresponding EC figure being 46%. Of the environmental topics studied the problem of noise is placed second in importance to 'deterioration of the landscape' on a European basis, whilst in the UK these two aspects are given joint first place. **Table 1** presents a ranking of the various environmental 'reasons for complaint' for the EC and the UK.

Some futher information from this EC study is worth reporting here. This relates to the effect of the living environment on a person's attitude to noise. The occupants of blocks of flats felt they had more reason to complain about noise than the occupants of individual dwellings. FIGURE 2

shows the differences in attitude according to dwelling type. This finding will no doubt influence both the preventative and remedial policies of local authorities.

Economy or Environment?

Various public opinion surveys, co-ordinated by the Organisation for Co-operation and Economic Development between 1982 and 1984, showed that in Europe and the USA only a minority of the public are prepared to sacrifice environmental protection in order to give priority to economic growth, given a choice of these options.

The following is an example of the kind of question used.

> 'Here are two opinions which are sometimes heard in discussion of the environment and economic growth. Which of them is closer to your point of view?'
>
> 1. Priority should be given to protecting the environment even if this means restricting economic growth.
>
> 2. Priority should be given to economic growth even if the environment suffers as a result.

Responses to the question are given in **Table 2** for the UK, EC and USA (Refs. 2, 3) and show public opinion to be very much in favour of protecting the environment, and this would be in spite of national/regional economic problems occurring at the time the surveys were being conducted.

ATTITUDES TO NOISE: EC AND UK

The European Omnibus Survey No. 16 (1981) (Ref. 4) presents the results of questions, about noise at home, put to 9697 persons in ten countries of the European Community. The questions dealt with fifteen different kinds of noise to identify noise exposure and annoyance. The noise types included 6 noises from outside (e.g traffic); 3 industrial noises; and 6 noises from neighbours. An index of noise exposure (based on scaled responses to the question - "Can you tell me how often this noise occurs?") showed the

highest UK and EC **exposure** frequency indices to be:

motor cycles
cars and lorries
barking dogs

To identify noise annoyance a ten point scale was used and average annoyance scores for each noise source produced. In rank order of annoyance value the principal sources were:-

UK	EC
motor cycles	motor cycles
barking dogs	cars and lorries
radio, T.V.	barking dogs
cars and lorries	pneumatic drills
people shouting (neighbours)	

Table 3 shows all the noise sources considered by the survey and these are listed in rank order according to frequency of hearing and annoyance. The highest rank number (15) indicates the most frequently heard noise or the most annoying noise. Considering the information in Table 3 the three noises which are most frequently heard and cause the most annoyance in the UK are:-

motor cycles
barking dogs, and
cars and lorries

Two other distinct noise categories can be identified.

There are some noises where the annoyance rank number is much greater than the frequency of hearing rank number - this implies that these noises are unacceptable when they are heard. Examples of this group are unlikely to be tolerated:-

Radio, TV (neighbours)

Workshops, factories

Pneumatic drills

Another group of noises includes those where the annoyance

rank number is much less than the frequency of hearing rank number; by comparison, the suggestion is that these noises are likely to be tolerated to some extent. Examples are:-

Sirens (emergency services)

Car doors (slamming)

The indices used to prepare Table 3 representing the frequency of hearing the noises and the degree of annoyance have been plotted in FIGURE 3 to show the correlation between noise exposure and annoyance for UK with relatively high exposure and low annoyance (eg sirens) and those with a high annoyance score relative to the degree of exposure. (eg pneumatic drills).

ATTITUDES TO ROAD TRAFFIC NOISE

Road traffic has long been regarded as the most widespread source of noise exposure and annoyance in the UK. A report (Ref. 5) commissioned by the Department of the Environment in 1971 (published in 1978) was based on a national sample survey in England of attitudes to, and effects of road traffic noise. The results with regard to noise are relevant in the context of this paper. FIGURE 4 shows the dominance of road traffic as a source of noise annoyance. Although some noise categories differ there are similarities in the relative proportions of persons annoyed when compared with MACCANC's survey (see later).

In the DOE's study respondents were asked about the types of traffic noise that bother people in the home and these results are given in FIGURE 5. Motor cycles then, are the element of traffic noise causing most bother to people at home but strangely the report makes no mention of this finding: although subsequent official commentaries (Refs. 6, 7) on the survey concede that motor cycle noise is particularly irritating.

ATTITUDES TO NOISE - MACCANC AREA

In the summer of 1985 the attention of MACCANC (see

APPENDIX 1) was focussed on the wide-ranging sources and differing impacts of environmental noise. At the same time there was considerable interest in complaints made by local residents to councillors about motor cycle noise. It was agreed that a study should be made of a range of environmental noise sources by surveying the opinions of a representative sample of residents of the MACCANC areas. This study was to be based on responses to a questionnaire posted to individuals.

The sample of residents was drawn at random from the electoral registers of the Councils. The total number of names and addresses selected was 1280 and it was hoped that around one thousand completed questionnaires would be returned; an expected response rate of approximately eighty per cent. It was recognised that there could be undue bias if each council selected an equal number of residents, and thus the numbers selected were weighted to ensure proportionality according to the population size of districts.

The questionnaire, together with an explanatory letter, was sent out on the 2nd September 1985 followed by a reminder letter two weeks later. The questionnaire addressed to a specific person asked about attitudes to noise and the degree of annoyance caused by a variety of noise sources, ie:

industry
neighbours
trains
aircraft
road traffic
motor cycles (on roads)
motor cycles (on land)
schools
entertainment (pubs/clubs)

The response to the questionnaire was very good and in total approximately 70% (887) of the forms were satisfactorily returned. The percentage of returns received by individual Local Authorities was also good and reasonably consistent, with twelve of them receiving at least 65% of questionnaires despatched. Macclesfield, the highest, had 89% (57) questionnaires returned.

RESULTS

For the sake of simplicity and clarity, the most important questions and answers are given below.

Q. Would you describe your area as

Very noisy?
Noisy?
Quiet?
Very quiet?

A. Very noisy - 5.3%
Noisy - 54.9%
Quiet - 30.8%
Very quiet - 9.0%

Q. Recently, have you heard noise from any of the following things WHILST AT HOME?

INDUSTRY
NEIGHBOURS
TRAINS
AIRCRAFT
ROAD TRAFFIC
MOTOR CYCLES (ON ROADS)
MOTOR CYCLES (ON LAND)
SCHOOLS
ENTERTAINMENT (PUBS, CLUBS)

A. (In ranked order)

ROAD TRAFFIC	48% heard
MOTOR CYCLES (On roads)	46%
AIRCRAFT	33%
NEIGHBOURS	29%
MOTOR CYCLES (On land)	13%
TRAINS	12%
ENTERTAINMENT (Pubs, Clubs)	11%
INDUSTRY	10.5%
SCHOOLS	6%

Q. Please indicate how you have been BOTHERED by noise recently from the following WHILST AT HOME.

(Same list of sources used as above but respondents asked to indicate the degree of bother as either, VERY MUCH, QUITE A LOT, A LITTLE, OR NOT AT ALL).

A. (By allotting a score of 3 for 'Very Much', 2 for 'Quite a lot' and 1 for 'A little' an index is calculated, and the sources are then ranked according to this index)

	Annoyance Index	Rank
ROAD TRAFFIC	.83	1
MOTOR CYCLES (On roads)	.76	2
NEIGHBOURS	.45	3
AIRCRAFT	.43	4
MOTOR CYCLES (On land)	.23	5
ENTERTAINMENT Pubs, Clubs)	.20	6
INDUSTRY	.18	7
TRAINS	.13	8
SCHOOLS	.08	9
OTHERS (specified by respondent) the two main groupings were:-		
'people' (mainly children/youths)		.13
'animals' (mainly barking dogs		.10

FIGURE 6 presents the above information according to the distribution of percentages of respondents reporting that they are bothered by noise.

Differences between Local Authorities

Survey results have been examined to identify differing response between the 15 districts. Overall there is little variation in the major sources of noise but motor cycles and aircraft in a minority of areas are prominent in annoyance terms over road traffic. The differences (or similarities) are:-

(a) MOST annoying source (overall = Road Traffic)

ROAD TRAFFIC - 10 LAs
MOTOR CYCLES (On roads) 3 LAs
AIRCRAFT - 2 LAs

(b) SECOND most annoying source (overall = Motor Cycles On Roads)

MOTOR CYCLES(ON ROADS) 10 LAs
ROAD TRAFFIC - 3 LAs
NEIGHBOURS - 2 LAs

(c) THIRD most annoying source (overall = Neighbours)

NEIGHBOURS - 8 LAs
ROAD TRAFFIC - 2 LAs
AIRCRAFT - 2 LAs
MOTOR CYCLES(ON ROADS) 1 LA
MOTOR CYCLES(ON LAND) 1 LA
INDUSTRY - 1 LA

Differences between Age Groups

Respondents were asked to say which age group they belonged to.
The following 5 groupings were used:-

Under 21 years
21 - 30
31 - 45
45 - 65
Over 65

Differences (or similarities) are as below:-

(a) MOST annoying source (overall = Road Traffic)

ROAD TRAFFIC - 3 age groups
MOTOR CYCLES(ON ROADS) 2 age groups

(b) SECOND most annoying source (overall = Motor Cycles On Roads)

MOTOR CYCLES (ON ROADS) groups

ROAD TRAFFIC - 2 age groups

(c) THIRD most annoying source (overall - Neighbours)

AIRCRAFT - 3 age groups
NEIGHBOURS - 2 age groups

SUMMARY OF SURVEY FINDINGS

This section brings together the main findings of the surveys referred to in this paper.

Environmental factors are important in European opinion and noise is of major significance. In the UK in terms of concern for the local environment noise is first equal with deterioration of the landscape; 34 per cent of UK residents feeling they have reason to complain about noise.

In the UK 50 per cent of people are in favour of giving priority to protecting the environment even if this means restricting economic growth; and only 36% said economic growth should have priority.

In Europe the occupiers of blocks of flats said they had more reason to complain about noise than was the case with occupiers of individual dwellings.

According to an EC study the most widespread noise sources in the UK are cars and lorries, and motor cycles, but the most annoying UK noise is the motor cycle. Barking dogs are the second most annoying noise source. Some noises are more easily accepted than others even though they are often heard (eg sirens), whilst some sources of noise, although not heard very often are very annoying when they are heard (eg neighbours' radio and TV).

A national survey in England showed road traffic to be the most annoying source of noise with motor cycle components causing the most bother. A study in part of North West England found road traffic noise to be the most bothersome source, with motor cycle noise in a very close second place.

The presence of aircraft noise in some areas, however, upsets this finding on a sub-district basis.

DISCUSSION

Road Traffic

The surveys have confirmed the seriousness of road traffic noise as an environmental problem, yet in the UK policies for new development still permit housing to be built in close proximity to busy roads. Surely an attempt should be made through official guidance to prevent the occurrence of such noise annoyance situations and to promote proper planning control aimed at creating a satisfactory living environment. The present official guidance, DOE Circular 10/73 - Planning and Noise, is far too vague in this context and is in urgent need of revision.

General

The Wilson Report (Ref. 11) provided the first comprehensive view on the problem of noise. However, this Report appeared in 1963 and since that time there have been some attempts to control noise through legislation. But the problem remains, and is probably worsening, which suggests that there is a need for a new review of the present position to provide a new impetus for improved control in the future. This view was put forward by a recent report on Science and Technology in Local Government (Ref. 12).

CONCLUSIONS

1. Road traffic noise is a serious environmental problem and urgent action is needed to ensure preventative and remedial policies produce a real reduction in the numbers of people highly annoyed.

2. The component of road traffic noise giving rise to most disturbance is the motor cycle; therefore, effective enforcement procedures are needed to combat motor cycle noise.

3. In some areas aircraft noise is a major source of annoyance and more extensive schemes for the insulation of dwellings are required.

4. Building Regulations, old and new, fail to bring into reality sound insulation objectives, and a proper building control mechanism is needed to ensure that the dwellings people occupy will have adequate sound insulation.

5. A sustained programme of education should become an important feature of policies aimed at reducing noise annoyance from sources of all kinds.

6. An urgent review of the state of the problem of noise in the UK would provide a suitable base for new policies.

ACKNOWLEDGEMENTS

The support and co-operation of the elected members and officers of MACCANC authorities is greatly appreciated. Also the computer work carried out by M.J. Nicholle (Bolton M.B.C.) has been invaluable.

TABLE 1 - Indices of dissatisfaction with environmental matters, UK, EC (1982)

	Index	
	UK	EC
Deterioration of the landscape	.65	.88
Noise	.65	.83
Air pollution	.54	.79
Loss of good farmland	.53	.75
Lack of access to open space and countryside	.38	.62
Drinking water purity	.28	.60

TABLE 2 - Public Opinion on Environment versus Economic Growth Options

Choice: Protection of the environment or economic growth?

Region	(date)	Env. %	Growth %	Don't Know %
UK	(1982)	50	36	14
EC	(1982)	59	27	14
USA	(1984)	62	28	10

TABLE 3 - Noise source ranking according to frequency of hearing and annoyance (UK)

FREQUENCY OF HEARING	RANKING
Cars and lorries	15
Motor Cycles	14
Barking Dogs	13
Car Doors	12
Sirens	11
People shouting (street)	10
Shouting (neighbours)	9
Aircraft	8
Radio, TV (neighbours)	7
Slamming doors (neighbours)	6
Footsteps	5
Water pipes	4
Pneumatic drills	3
Construction machinery	2
Workshops, factories	1

ANNOYANCE	RANKING
Motor Cycles	15
Barking dogs	14
Radio, TV (neighbours)	13
Cars and lorries	11.5
Shouting (neighbours)	11.5
People shouting (street)	9.5
Slamming doors (neighbours)	9.5
Pneumatic drills	8
Car doors	7
Workshops, factories	6
Construction machinery	5
Aircraft	4
Footsteps	3
Water pipes	2
Sirens	1

APPENDIX 1

THE MANCHESTER AREA COUNCIL FOR CLEAN AIR AND NOISE CONTROL (MACCANC)

MACCANC comprises elected members of sixteen local authorities in the North West of England. The Council receives reports from its technical committees of officers and its aim is to act as co-operating body on all matters concerned with the control of air pollution and noise.

The constituent local authorities of MACCANC are:-

Bolton Metropolitan Borough Council
Bury Metropolitan Borough Council
High Peak Borough Council
Macclesfield Borough Council
Manchester City Council
Oldham Metropolitan Borough Council
Rochdale Metropolitan Borough Council
Rossendale Borough Council
Salford City Council
Stockport Metropolitan Borough Council
Tameside Metropolitan Borough Council
Trafford Metropolitan Borough Council
Warrington Borough Council
West Lancashire District Council
Wigan Metropolitan Borough Council

Cheshire County Council (new member)

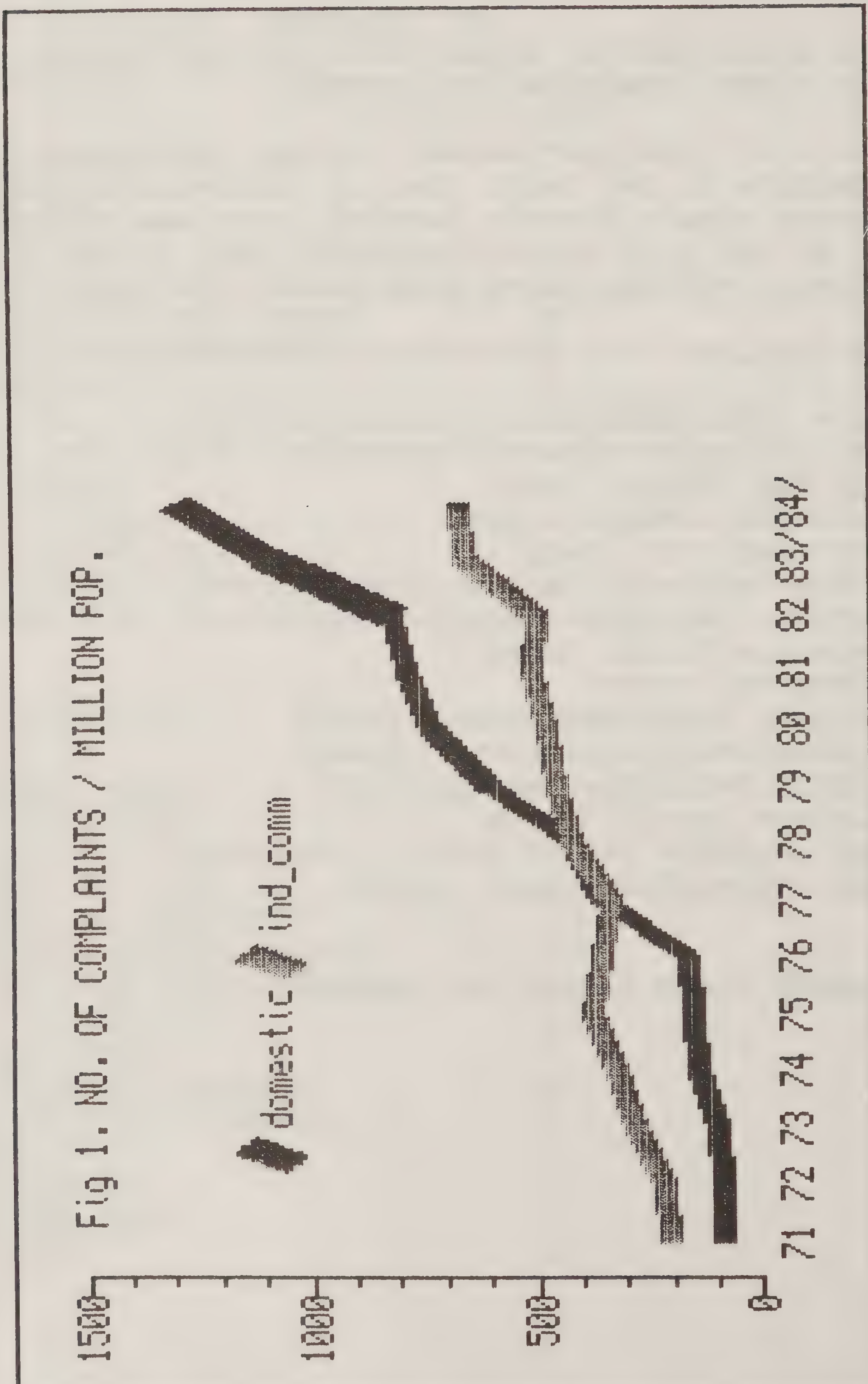
Fig 1. NO. OF COMPLAINTS / MILLION POP.
domestic
ind_comm
1500
1000
500
0
71 72 73 74 75 76 77 78 79 80 81 82 83/84/

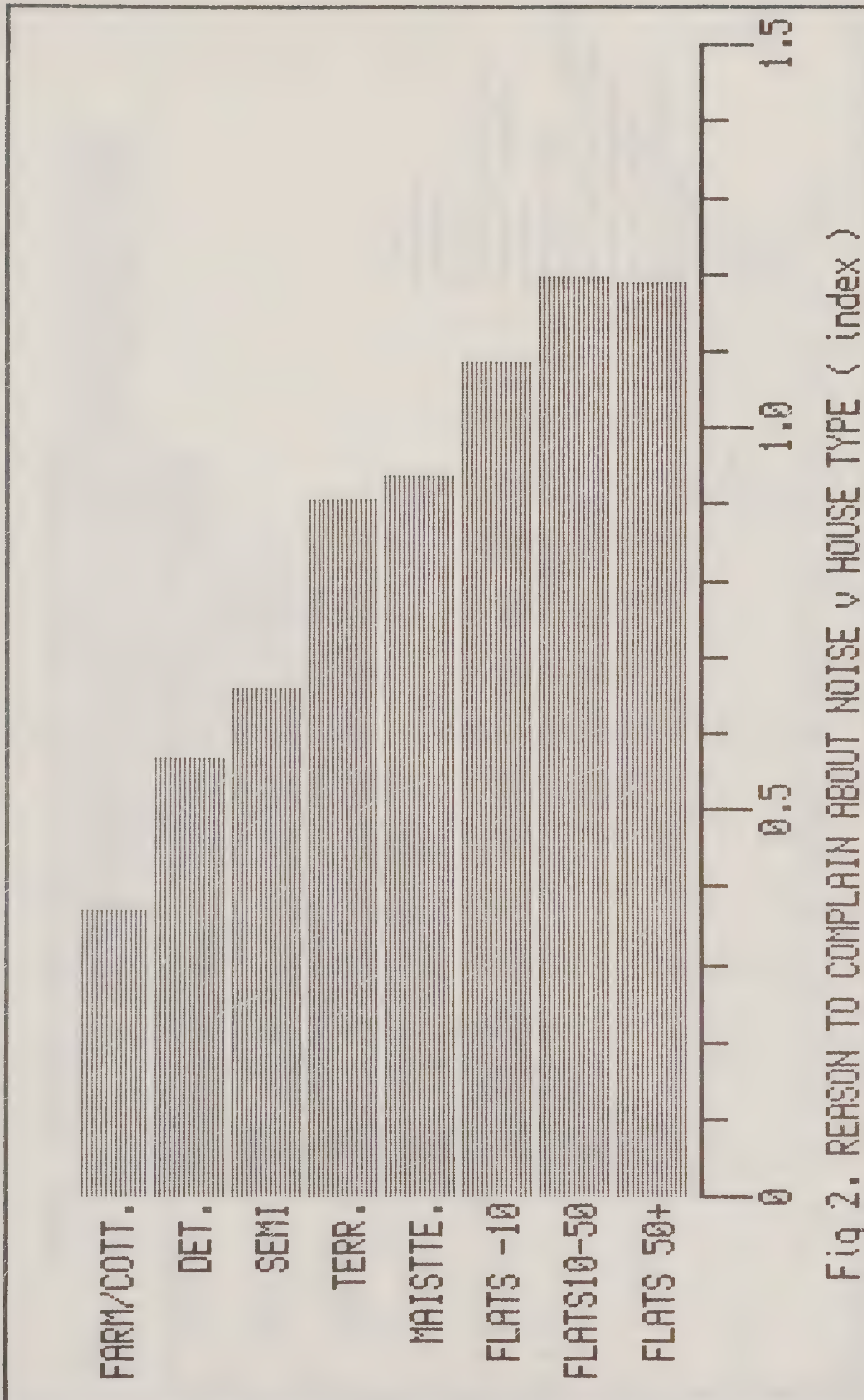

Fig 2. REASON TO COMPLAIN ABOUT NOISE v HOUSE TYPE (index)

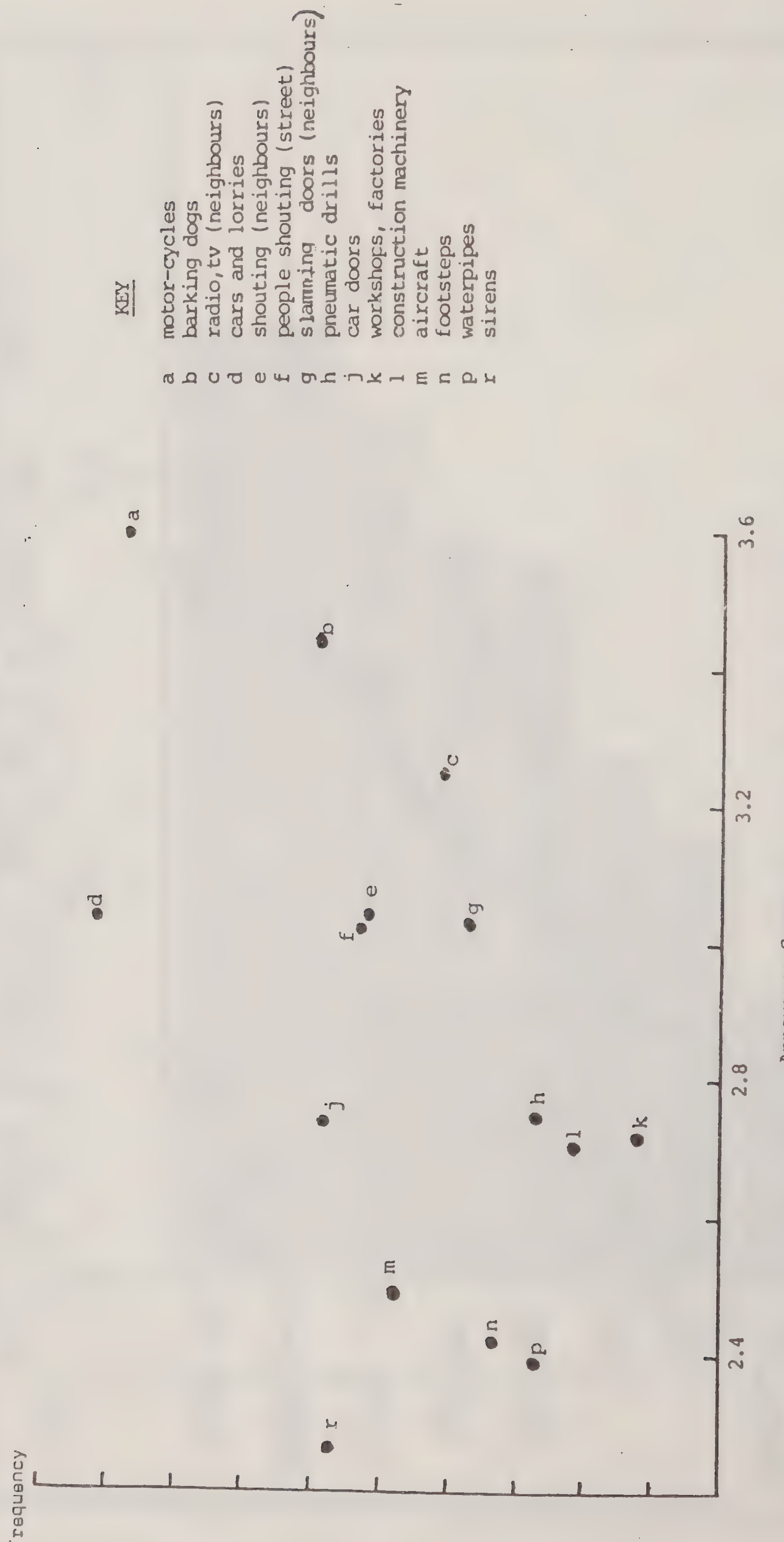

FIGURE 3 Relationship between frequency of exposure to noise and annoyance

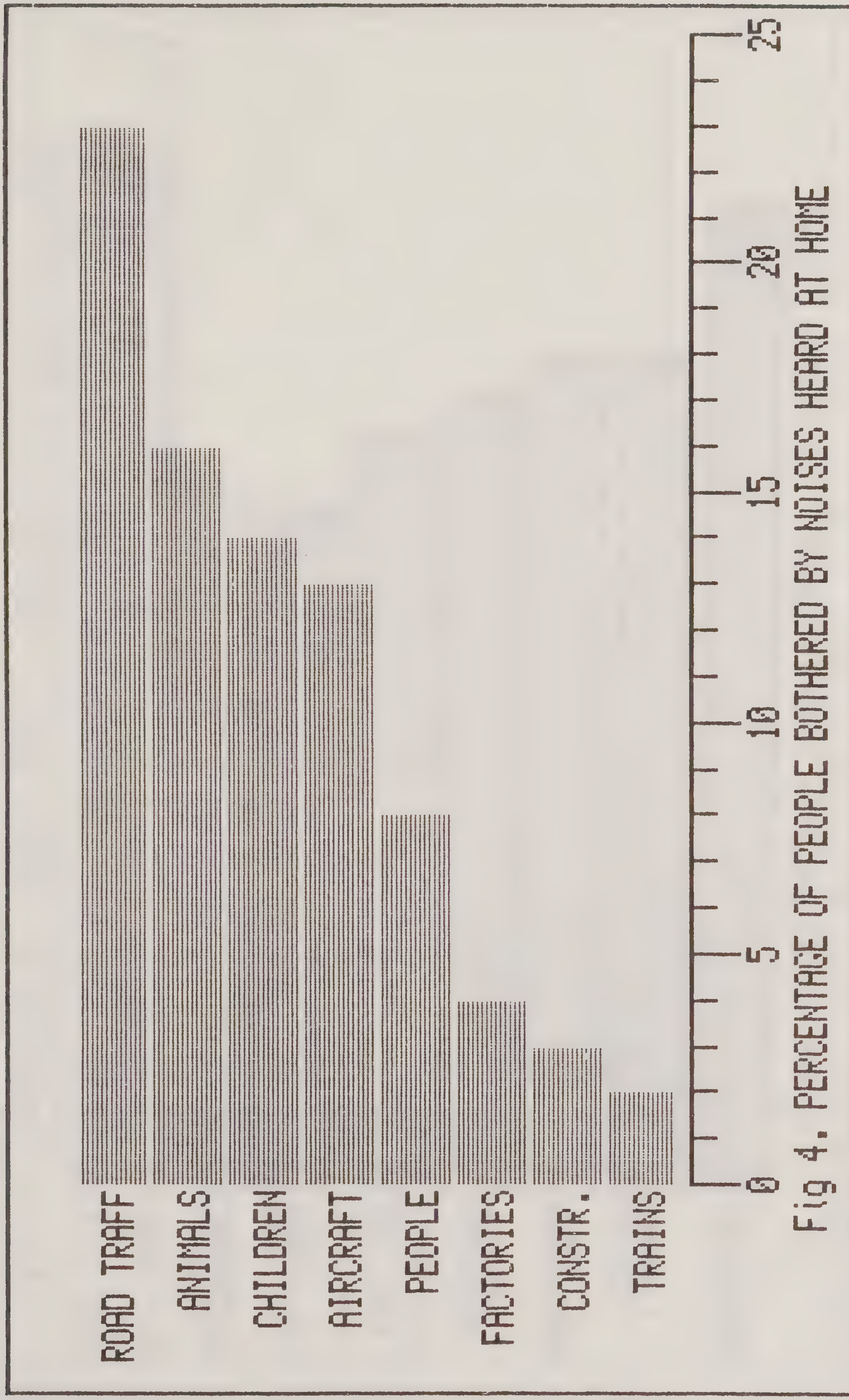

Fig 4. PERCENTAGE OF PEOPLE BOTHERED BY NOISES HEARD AT HOME

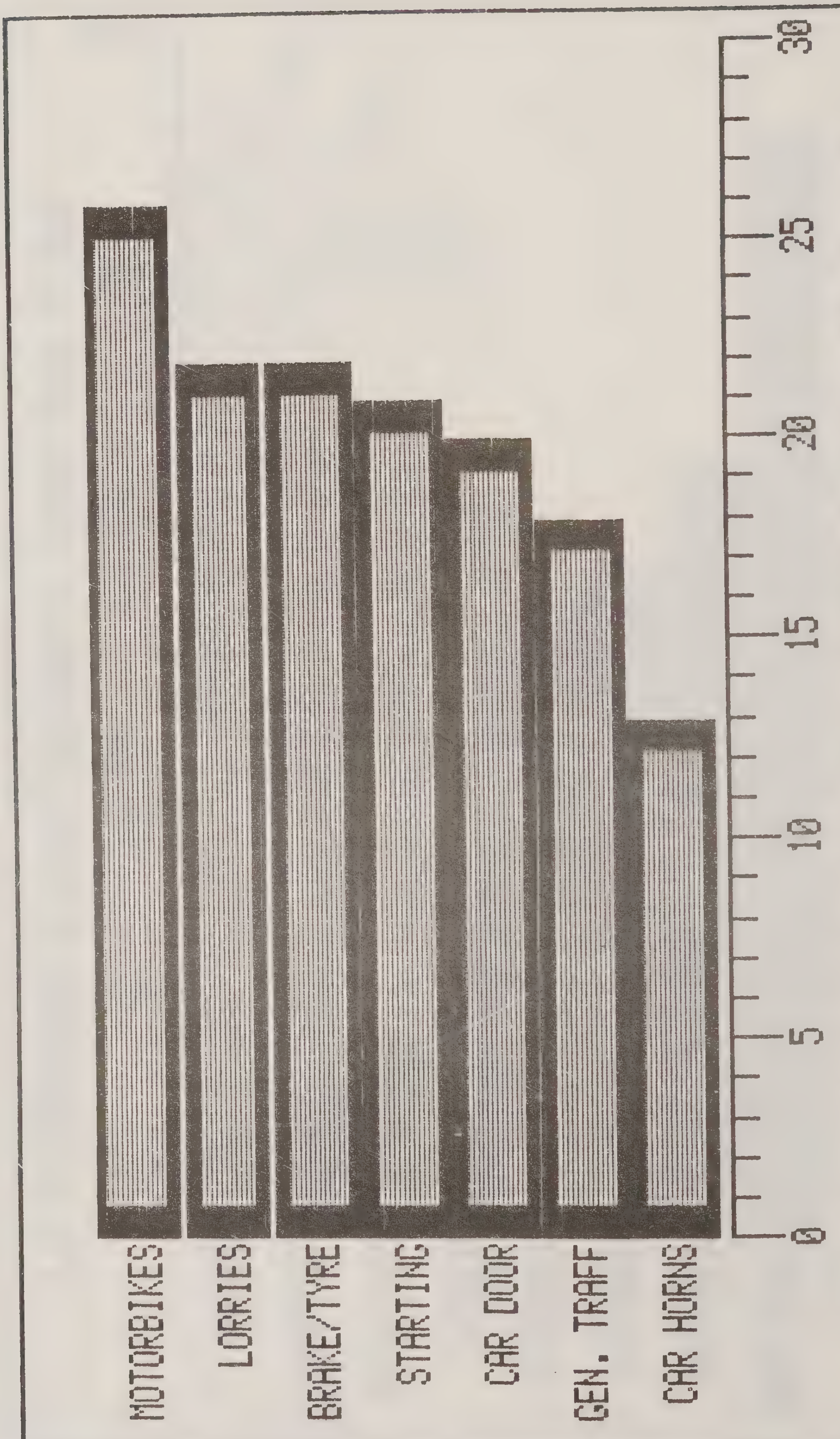

Fig 5. COMPONENTS OF TRAFFIC NOISE - PERCENTAGE OF PEOPLE BOTHERED

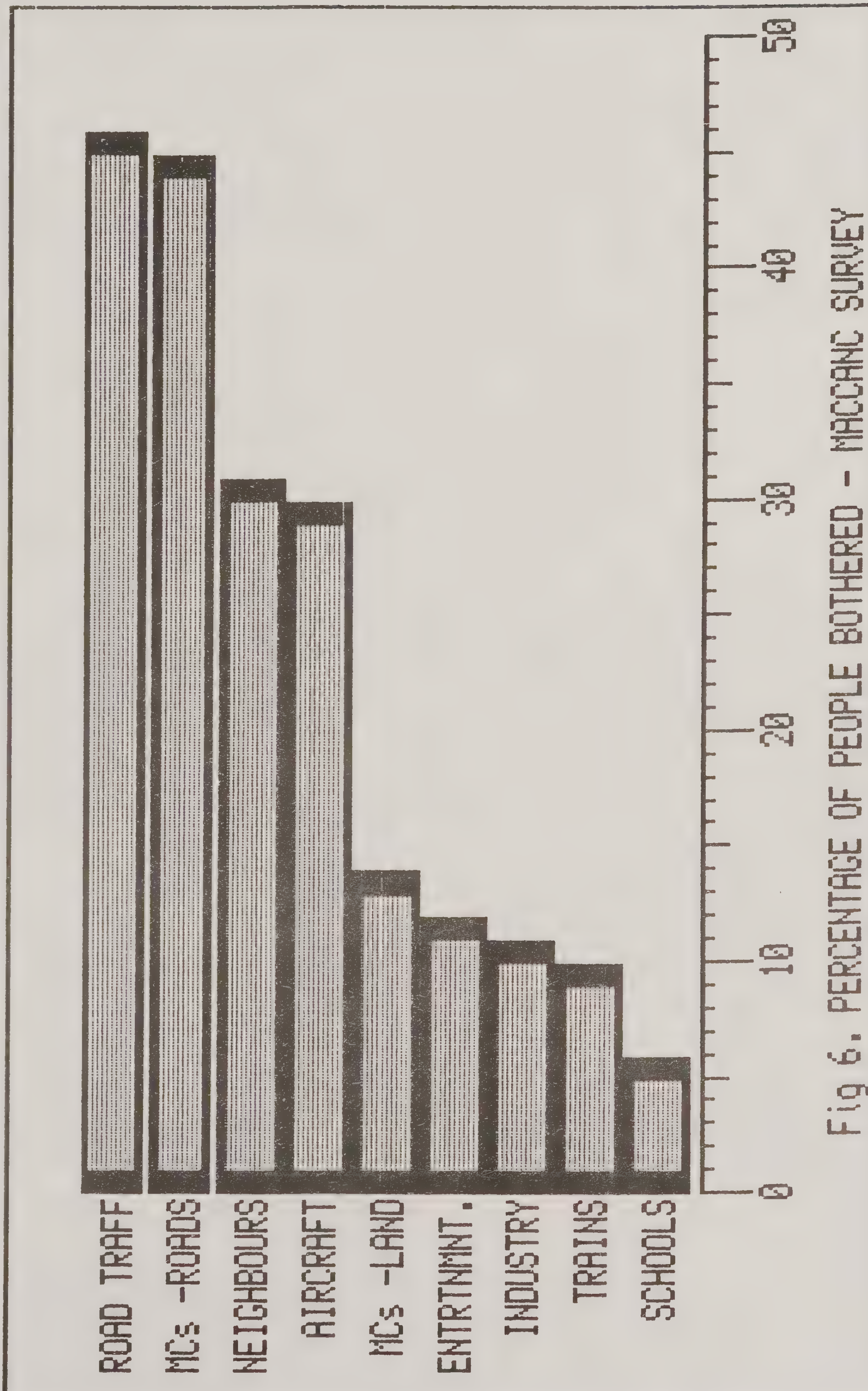

Fig 6. PERCENTAGE OF PEOPLE BOTHERED - MACCANC SURVEY

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PRESENTATION ON MOTORCYCLE NOISE

– By –
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PRESENTATION ON MOTORCYCLE NOISE

by
A.J. Gibbon

One of the reasons I detailed the legislation in my written paper was that I wished to avoid too much reference in my presentation to the very complex set of differing standards, measurement techniques and the decibel number jungle - which, unless you study them regularly, remain a maze of European and UK law.

Another reason is that having spoken with elected members of my own authority and those from adjoining authorities, I am left with the distinct impression that they are no longer interested in a "number crunching" exercise explaining why enforcement action is often impracticable and impossible.

Instead, elected members and the public want answers to the following questions.

1. Why do some motor cyclists continue to ride very noisy motor bikes in quiet urban areas, often late at night, in the process annoying residents?

You've all heard them - the noisy rattle that can be heard for a long time as the bike drones away in the distance.

2. Why are people constantly annoyed by noisy bikes whilst out walking, or why should they have their conversations drowned by some motor cyclist racing away from traffic lights?

3. Why does it appear that groups of teenagers can whiz round housing estates on noisy little motor bikes causing a noise nuisance?

4. What good are all these EEC regulations? There are more smaller motor bikes on the road and the noise is just as bad.

And finally,
5. What changes in the law should be made in order to provide an effective means of controlling the noise from motor bikes when in use on the road?

I was hoping to address these questions without referring to the complicated legal situation and its decibel jungle. However, since my paper was printed the law has undergone a very recent and significant review. I will therefore have to outline the changes which fortunately have cleared away some of the drawbacks.

The major instrument is now the Motor Vehicles (Construction and Use) Regulations 1986, which came into force on 11 August 1986.

Those of you who have read my paper or have dealt with the problem of motor bike noise will have realised two things:

1. the noise limits specified in the 1978 Regulations, designed to control the noise from motor bikes in use on the roads, are virtually worthless. These "Use" noise levels were hardly ever used because the specified noise testing conditions are so technically impractical that the law was unenforceable;
2. the noise limits specified for new motor bikes constructed after various dates, that is the "Construction" noise levels, are clearly only intended to control motor bikes at the time of manufacture or when first used on the road. Any changes or deterioration in the silencer after that time are outside the construction noise limitations.

Happily, the Construction and Use Regulations 1986 have recognised the worthless nature of the "Use" noise levels, and they have been removed. I see this has having possible benefits to which I will refer later.

The important parts of the controls have been retained and, hopefully, these can be strengthened by some future legislation which will control "Use" noise without recourse to complicated noise test procedures.

Briefly, the new law retains the existing "Construction" noise

level limits for new bikes first used after various dates:

1. 1st April 1970 to March 1983
2. after 1st April 1983, and
3. with a proposal to further reduce noise limits in 1987 and 1995 by EEC legislation.

The newer the bike, the more restrictive the noise limits.

I wish to spend as little time as possible on "Construction" noise limits but it is important to realise that their role in practical terms is potentially limited to the life span of the original manufacturer's exhaust silencer. For example, the new 125 cc motor bike complying with the construction noise limit of 80 dB(A) on the 1st April 1983 may at a later date have a modified or low quality silencer fitted which could increase the noise level to 110 dB(A) under high revving conditions. Evidence given to the House of Lords Select Committee shows that approximately 1.3 million motor bikes are currently used on the roads and it is estimated that 35% have illegal silencer systems.
Furthermore, it is estimated that 60,000 illegal replacement silencer systems are sold every year.

I have previously referred to the proposed EEC Regulation 948 which is designed to reduce further the noise level at the time of manufacture or first use in two stages, ie after 1987 and 1995.

Some of the currently held views regarding these proposed EEC standards are:

1. the proposed noise reductions are less than those required by the DoT and the House of Lords Select Committee supports the DoT in their efforts to obtain further reductions before the EEC law is implemented;
2. in the 125 cc class there is no reduction at all until 1995;
3. proposed changes in the acceleration test criteria may negate some of the proposed noise level reductions;
4. few people would disagree with the view expressed by the NSCA in its evidence to the House of Lords Select Committee that whilst this law encourages the development of less noisy motor cycles, it is thought that too much emphasis is given to the tightening up of type approval standards and too little emphasis laid on

discouraging deliberate tampering with the silencer or driving in an inconsiderate manner;

5. without additional and effective "Use" noise legislation to control the standard of replacement silencers, the effects of "Construction" regulations can be limited to the life span of the original silencer.

1986 Regulation 57(3) reinforces an important control made in 1984:

> "The silencer which forms part of the exhaust system of a motorcycle first used on or after 1st January 1985 shall be either:
>
> (a)that with which the vehicle was fitted when it was manufactured; or
>
> (b)clearly and indelibly marked with either:
>
> (i) the British Standard marking indicating that it has been tested in accordance with test 2; or
>
> (ii) a reference to its make and type specified by the manufacturer of the vehicle."

The above means that a motor bike complying with the current "Construction" noise standards and first used on the road after 1st January 1985 shall in effect have to continue to comply by only having a manufacturer's bona fide replacement silencer fitted or one stamped with British Standard BS AU 193 test 2.

This piece of legislation is estimated to apply to a quarter of a million motor bikes, but whilst this is a very welcome improvement in control, we should remind ourselves of the one million or so motor bikes presently on the road to which this regulation does not apply, especially when it is known that the average life span of a motor bike is in the region of 5/10 years. We desperately need legislation to control the standard of replacement silencers for this one million motor bikes.

The House of Lords Select Committee opined that priority should be given to dealing with the problems arising from exhausts which have been tampered with or have deteriorated or have been fitted with unsatisfactory replacement systems. The Committee believe that the single most effective measure would be to control the sale of replacement exhaust systems and recognise that for this to be done at national

level would require new primary legislation.

An attempt was made by the DoT to control the standard of silencers at the point of sale by using the Consumer Safety Act. This unfortunately stretched the concept of consumer safety and the DoT withdrew this proposal following legal advice. However, I understand from the DoT that they are currently pursuing the introduction of enabling legislation under consumer protection law which would effectively control the standard of replacement silencers at the point of sale. This would apply to replacement silencers for motor bikes first used after the 1st April 1970.

The offence would be to sell:

BS AU - 193 (1983) TEST 1. for 1970 - 1983;
BS AU - 193 (1983) TEST 2. for 1983 - onwards.

I understand that there is a possibility of this legslation beginning life as a private member's bill, following a ballot on the 24 November 1986. (EDITOR'S NOTE: Robert Adley, MP, subsequently introduced a Private Member's Bill to curb the sales of noisy replacement silencers for motorcycles, which went to the House of Lords after receiving an unopposed third reading in the Commons on 24 April 1987. The Bill would enable the Secretary of State to make regulations requiring replacement silencers to be marked with a British Standard number. Enforcement of the ban on sales of unmarked silencers would rest with local authority trading standards officers.)

A further control of "Use" noise level is contained in Regulation 54 (2) ie

> "Every exhaust system and silencer shall not be altered so as to increase the noise made by the escape of exhaust gases."

Then there is Regulation 97, which says that no motor cycle shall be used on a road in such a manner as to cause excessive noise which the driver could have avoided by the exercise of reasonable care.

I have referred previously to the removal from the 1986 Regulations of the "Use" noise levels and testing procedure. There is a view in the document prepared by MACCANC*

that one of the possible difficulties in enforcement based on the subjective assessment of excessive noise was the existence of a clearly defined although impractical noise test, and that perhaps there may have been a possible legal defence that the noise was not excessive unless it could be proven that the old "Use" noise limits had been exceeded. However, we now have the situation where the only test is the subjective opinion of a police officer. I would suggest that a more rigorous police enforcement of Regulations 57 and 58 could be promoted.

We are all aware of the new fixed penalty legislation for road traffic offences (some of you may have already have personal experience of these!) and from discussions with the police authority in my area it would appear that failure to maintain an effective silencer or causing avoidable excessive noise are offences for which a fixed penalty ticket can be issued. I would suggest that here lies one additional, practical way of dealing with unnecessary noise.

It may be difficult for the police to take action against a motor cyclist riding a bike with a legal silencer, but surely there can be no defence in the case where it can be shown that a motor bike has an illegal silencer. It may well be that a number of successful fines would soon have the desired effect nationally. Indeed the Motor Cycle Association of Great Britain has already published literature which spells out the fixed penalty situation.

* MACCANC - Manchester Area Council for Clean Air and Noise Control.

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BLACKPOOL

OZONE PRODUCTION DOWNWIND OF LARGE CONURBATIONS

— By —
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OZONE PRODUCTION DOWNWIND OF LARGE CONURBATIONS

by
Dr. A.R.W. Marsh

Ozone and the Los Angeles smog situation is one of the foundation stones of atmospheric chemistry, along with the London smogs of the 1950s, so the questions in terms of an urban environment are: what is new about the ozone problem, why are we still concerned, and why hasn't the problem gone away.

"The problem" is that excess ozone is a symptom and a product of complex photochemistry, and does, in itself, cause damage to crops and affect human health. The levels in Los Angeles are still very much higher than are found anywhere else but there is some evidence that ozone concentrations in industrialised areas are increasing significantly.

Since the initial investigation in the 1960s of the Los Angeles smog, the same problem has become slowly apparent at a number of sites around the world, eg in Sydney and Tokyo. Ozone has relatively recently been cited as one of the primary stress factors in the decline of the German forests. In the UK since about 1976 we have recognised that we do not escape the ozone problem either. Initial effects on human health and on crops begin to be manifested at ozone levels of about .1 ppm of ozone in the atmosphere. That value has been exceeded every year in the UK since 1973, and in 1976, which I think we all remember as a nice hot year, that value was actually exceeded by a factor of 2. But the British summer is not exactly reliable as 1986 has proved, so that the number of occasions on which high values are recorded in England is very variable. The .1 ppm value might be exceeded on fifteen days a year one year, and perhaps as many as fifty in an unusual year such as 1976.

In order to understand the origin of such values, we must

consider the behaviour of ozone in the atmosphere. Sources of the primary pollutants involved are power stations, urban areas generally, and traffic. Ozone is a little different from normal pollutants in that the maximum levels occur at high level in the stratosphere. Closer to the ground there is a turbulent mixing layer which is about 1 km or 3,000 ft deep on average. The material in this lower level can mix with diffusing plumes from power stations or urban sources, and gas-phase chemical reactions can occur in this part of the atmosphere. One or two loss mechanisms are also important - if gases are taken up by surfaces, like the land and the sea, then this is a loss process from the lower levels of the atmosphere. Indeed, at night ozone is lost by this process to the ground, a point I shall return to later. Another loss mechanism is gas-phase reaction, so that ozone can be both produced and removed by such reactions.

Ozone is not really soluble in water, so that removal processes in clouds and rain are not significant so far as ozone itself is concerned. However, the CEGB is interested in "acid rain" and ozone plays a role in that process too, in the sense that it can oxidise sulphur dioxide in cloud water - depending on the acidity of the cloud water - to produce sulphuric acid. Ozone is also involved in a chain of reactions producing free radicals. These free radicals react in the atmosphere to produce other oxidants, such as hydrogen peroxide, and that in turn can oxidise SO_2 to sulphuric acid. In fact, hydrogen peroxide has been suggested as a potential oxidant problem in its own right, particularly as far as plants are concerned, even at the very low levels, < 1 ppb, that exist in the troposphere.

Returning to the gas-phase reactions, the classic description of ozone in the atmosphere is, of course, its reactions with oxides of nitrogen.

(1) $O_3 + NO - NO_2 + O_2$

(2) NO_2 + SUNLIGHT - $NO + O$

(3) $O + O_2 - O_3$

The ozone concentration is related to the oxides of nitrogen, and also dependent on the sunshine intensity; the equilibrium is dynamic and a time scale of up to the order of minutes is required to establish equilibrium depending on the concentrations when the sun is shining. The equilibrium can be expressed as the ratio $O_3 * NO/NO_2$. If we can

postulate other reactions which alter this ratio, since this is in equilibrium, then the ozone concentration may be affected, giving excess ozone formation - "the ozone bulges" that are seen downwind of urban areas.

Other reactants that can lead to the enhancement of ozone are a whole range of hydrocarbons. Sources of hydrocarbons are both general industry and solvent use and of course motor vehicles, which in addition produce NOx and CO, that are in turn involved in the complex chemical reactions. The way that the hydrocarbons produce ozone is quite interesting. They are primarily destroyed by the hydroxyl free radical and through a sequence of reactions they eventually manage to convert NO to NO_2, thus altering the photo-stationary state equilibrium mentioned earlier. However, since ozone is responsible for producing the hydroxyl radical, there is a very involved, complex process of feed-backs and the only way to predict the outcome is by using complex numerical models of the chemistry which are evaluated using a computer.

Ozone formation can be very significant and relatively rapid. FIG 1 shows some ozone concentration profiles over the north-east coast of England, recorded as a result of straight line flights by an aeroplane containing instrumentation. The envelope represents the concentration profile of ozone. The object was to study the plume from Eggborough Power Station. The NO emissions from Eggborough Power Station caused a dip in the ozone concentration due east of the station on the near-field traverse, as can be seen from the figure. However, coincidentally there was a build-up of ozone coming from the Teesside-Tyneside area which was quite pronounced as a plume. The distance between the two tracks is about 100 km and corresponds to a travel time, as far as the air is concerned, of something like 3 or 4 hours.

In a discussion about the computer calculations models used to model these chemical reactions, it is important to understand their deficiencies as well as their successes. These models have to take into account several common physical features. It is essential to get the emissions of ozone precursors - the hydrocarbons, NOx etc - right in the model. These emissions vary according to the time of day,

so a diurnal cycle of emissions has to be taken into account. The dry deposition process for removing ozone from the atmosphere also varies according to the time of day. Ozone can be taken up more readily by plants than it is by soil and the plants respond to daylight by opening stomata etc. which in turn affects the removal of ozone. Similarly, the depth of pollution material in the atmosphere varies according to whether it is day or night. Although it might be assumed that this lower level is relatively impervious to the air above it, that is not strictly true. There is mixing with the air above and it is necessary to get that complex function of meteorology right in the models. Finally, of course, the sunlight has to be right for the time of day, and it is necessary to add in information about position on the earth's surface. Some of the models that have been presented over the years do not necessarily take into account all these features and it is true that they are probably better at describing the chemistry than they are at describing the physical parameters.

Looking at the chemical features of these models, there are considerable numbers of reactions to be taken into account. The inorganic chemistry is fairly well described by something like about 50 reactions and these work reasonably well, we think, for the daytime situation, although perhaps a little less well at night. The real problem with modelling the precursors of ozone is dealing with the organic material. In an ideal world every hydrocarbon of importance would be put into the model, with every reaction it could undergo; but that would run into several hundred reactions which would cause a problem with all but the most powerful computers.

Interest in many groups throughout the world has centred on alternative ways of representing organic material. The use of "representative species" is one such method. In this type of model real rate constants are used but the amounts of non-specific hydrocarbons are adjusted to account for the range of hydrocarbons in the atmosphere. Another way is to count the number of carbon atoms believed to be in the atmosphere and adjust their reactivity according to the type of organic material involved eg an alkane or an aldehyde. Both of these representations will enable a proper mass balance to be achieved for the amount of material in the atmosphere. Early attempts used so-called lump mechanisms,

involving "typical compounds" - hydrocarbons were referred to as R - and weighted rate coefficients were employed. Unfortunately this meant that a proper mass balance could not be achieved.

Having made these distinctions between the different sorts of models, it is necessary to examine how well they represent reality. The models have all been tested in a number of ways and compared with the Los Angeles smog simulation in laboratory studies in smog chambers. My models give a reasonable fit for that type of situation. Furthermore, most of the models agree very approximately on how much ozone is produced in the first day. The carbon bond model tends to give ozone production rather earlier in time than the other models. The problem with the models occurs when they are extended over several days. Then the differences between them become very apparent.

These models are designed to answer "what if?" questions and can be used to examine what might happen if control strategies are invoked to achieve reductions in hydrocarbons or oxides of nitrogen.

FIG 2 is a contour plot of ozone concentrations against hydrocarbon and nitrogen oxide concentrations. The ozone concentrations in the diagram represent those of a particular point in space and time, downwind from the sources of hydrocarbons and nitrogen oxides. It is clear from this diagram that increasing both hydrocarbons and nitrogen oxides means that more ozone will be produced. Starting with a fairly low level amount of oxides of nitrogen but fairly high amount of hydrocarbons, Pt A, and given a reduction in hydrocarbons to Pt B without a decrease in nitrogen oxides, this will result in an increase in ozone concentrations which is not desirable. Correspondingly, starting at Pt C with high levels of oxides of nitrogen and low hydrocarbons and given a reduction in oxides of nitrogen, ie moving to Pt B, would again produce more ozone. Thus this diagram demonstrates that doing what seems initially to be the obvious thing, ie reducing pollutants, does not always lead to the desired result.

This exercise can be taken a little bit further, looking at the sort of control strategies that have been discussed for motor

vehicles.

FIG 3, taken from the work of Adrian Hough at Harwell, illustrates that the calculations can be made for a variety of scenarios depending upon which set of reductions and emissions for motor vehicles is chosen. In Fig 3 the curve A represents the state of affairs on a summer day in 1984 and the others represent what might happen in the year 2000 if different strategies are adopted. Looking at Case B it appears that there is a reduction in ozone in the early stages of the day, which is good, but later on it actually becomes as high as the case where nothing at all is done. On the other hand, scenario E shows a considerably reduced maximum amount of ozone but in the early stages of the day the ozone is actually higher than it is in the base case A.

The essential point is that ozone and ozone production varies in space and time in a very complicated way; if you consider for example a puff of air leaving London and travelling westwards, a control strategy which might be good for Swindon could be bad for somewhere closer to London, say Ascot. So, controls have to take these spatial and temporal problems into account. If an air mass starts in London at midnight instead of 6 am, then these effects will be felt further away from the source.

FIG 4 shows some results from the London survey, which was set up by a number of institutes including the old GLC, Harwell, Warren Spring Laboratory and the CEGB. This illustrates the variation of ozone with space and time. At each site, ozone was monitored 24 hours a day and the results are given as hourly mean measurements. The top row of arrows shows the wind direction and the speed as seen from the top of the Post Office Tower. There was a fairly strong westerly wind throughout the 24 hours. It can be seen that there was little or no ozone production downwind of London. There was an ozone "deficiency" in central London, due to local NO production. On FIG 5, the same type of diagram, where there is an easterly flow, it can be seen that high ozone has been produced, particularly in the area of Ascot. However, it should be noticed that on the east coast of England the values are quite high too. That is an effect of another important feature, the plume

from Rotterdam and Holland. Material crosses the southern North Sea and comes into the country, then the chemical reactions associated with the London urban plume are superimposed on that old polluted air.

FIG 6 again shows some results from the London survey, this time with a north-easterly wind leading to a build-up of ozone south of London.

On this last occasion, 12 July 1984, aircraft measurements were made as well as the ground station observations.

The aeroplane that was used in tracking ozone was a Handley Page Jetstream owned by the Cranfield Institute of Technology, the CEGB being responsible for the measurements. The results obtained by the aeroplane as it flew round the circuit are interesting. FIG 7 shows the results for SO_2 and NOx. Large peaks are associated with the industry in the Thames Valley area, including the power stations of course, and these slowly decay away and by the time they reach the Channel they have dispersed into the background air. FIG 8 shows the results for the ozone and nitrogen dioxide, NO_2. There is very little NO_2 in the upwind area, but some conversion of the NO by ozone in the immediate area, producing a peak in NO_2 and a corresponding trough in ozone. But if we look at the general level of ozone and compare it with the levels found after passing through London, it can be seen that there has been a steady increase in ozone as the air moved over the area, which fits in with the ground level observations.

The object of the flight was to look at the ozone precursors, especially what happened to three particular hydrocarbons upwind of London and downwind of London. FIG 9 shows the results. Because London is obviously a source of these hydrocarbons, there was a general build-up of ethylene and acetylene. On the other hand, the other hydrocarbon depicted in this diagram, propene, first increases then levels off. Propene is very much more reactive than the other two and while it might be expected to increase steadily as the other two do, because it is so much more reactive, the concentration is depleted and the products of that depletion go towards increasing the ozone concentration.

Aided by these sorts of figures, it is possible to work out a number of parameters that can be compared directly with the computer models. In addition, of course, by measuring a whole range of hydrocarbons, it is possible to check the sources of hydrocarbons and compare these with the sort of emission figures that are necessary inputs for the computer models. It appears that the concentrations of some hydrocarbons like normal butane seem to be higher in the London area than the emission inventories would estimate. Unfortunately, normal butane has many sources, for example motor vehicles, the petroleum industry, natural gas leakage, etc so it is not apparent where an error might have been made. Another hydrocarbon that appears to be a little high is propane, so the error may be an underestimate of natural gas leakage in the area.

The above is a brief review of the experimental programme that we have undertaken to compare actual observations with the complex computer models. The conclusion of our work is that the models work well for the situation where little happens - ie where very little ozone is produced and the wind is strong. They also work if the wind speed is very low and the air is just gently cooking but not moving very far. The models can give reasonably good results under those circumstances. However, the models do not work well when, for example, the Rotterdam plume is coming into the London area and the London pollution is being added to the "old" pollution being brought into the country. Under those circumstances, the models do not seem to be able to make ozone quickly enough and we seem to observe more than the models would suggest.

The conclusion of all this work is that we need to know the sources of hydrocarbons and we need very good inventories; a combination of measurements and estimates from industry is required here. The modelling can give a good qualitative feel of what is happening but the current generation of computer models should essentially be regarded as research tools and they are not really good enough yet for legislation. As Dr. Jenkins' talk showed earlier, not all the aspects of ozone chemistry, even in the stratosphere, are fully understood. I think the same applies to the lower levels of the atmosphere and the troposphere as well.

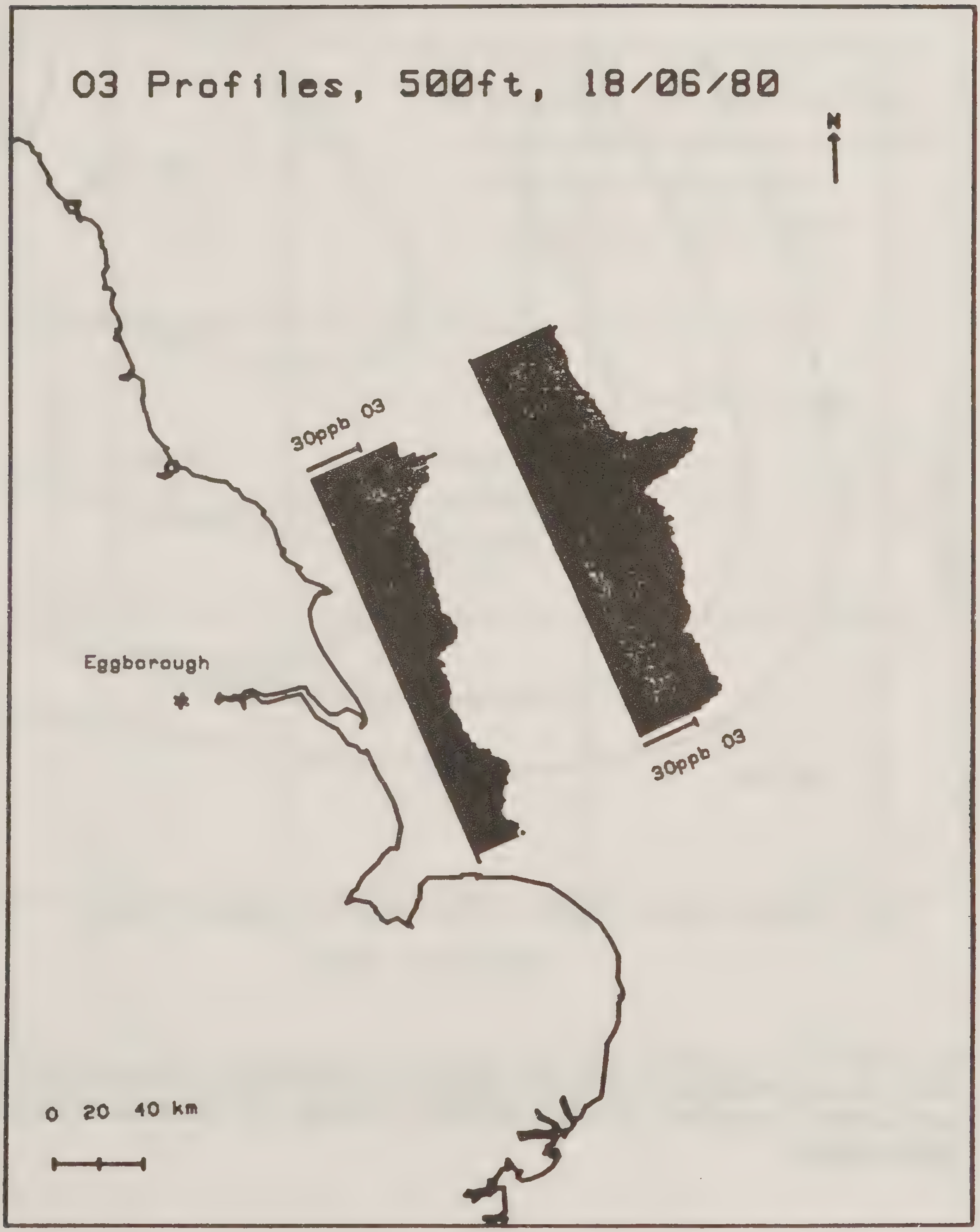

FIG 1 Ozone concentrations of the NE coast

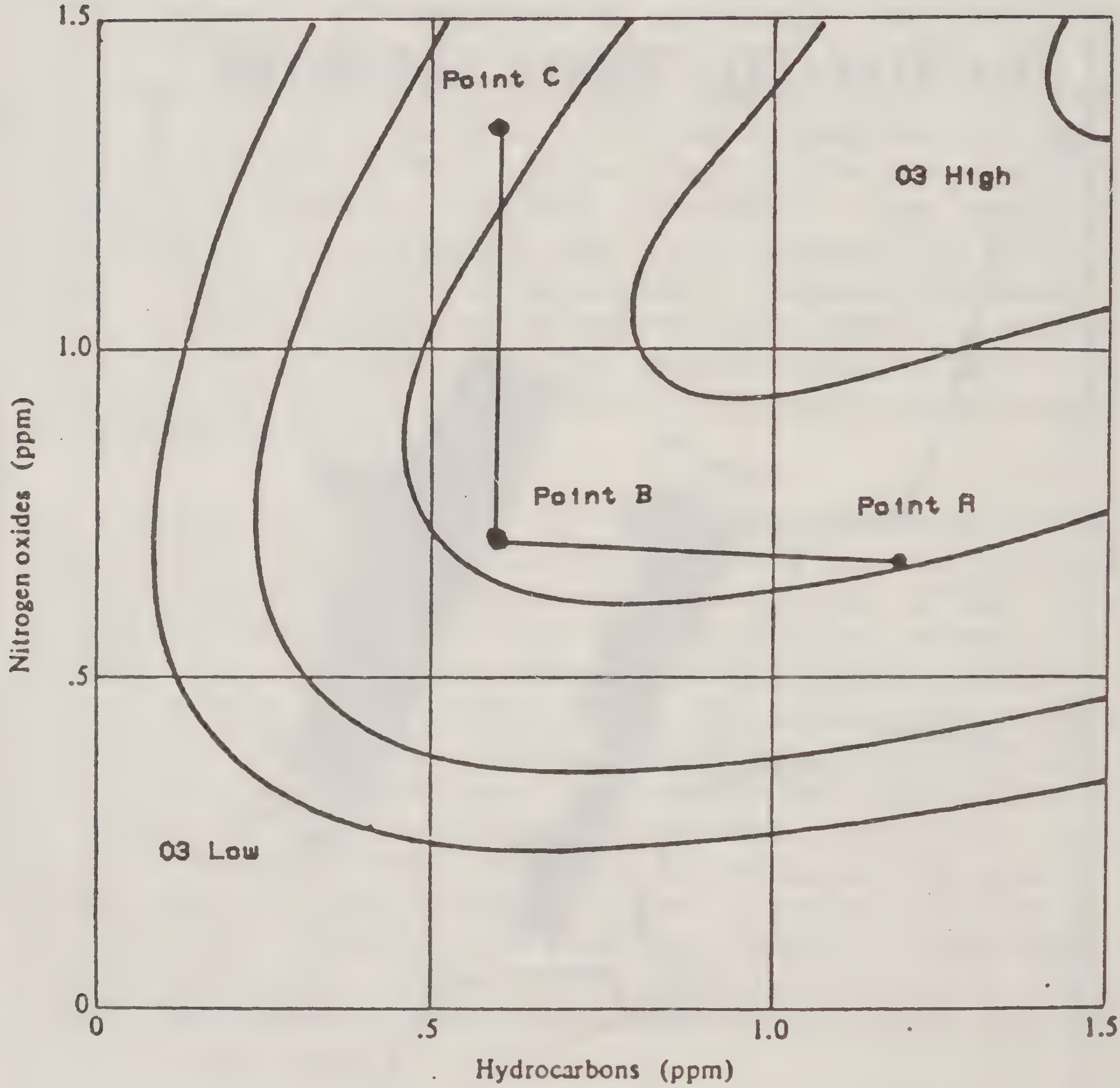

FIG 2 Contour plot of ozone formation downwind of pollution sources after several hours of photochemical reactions

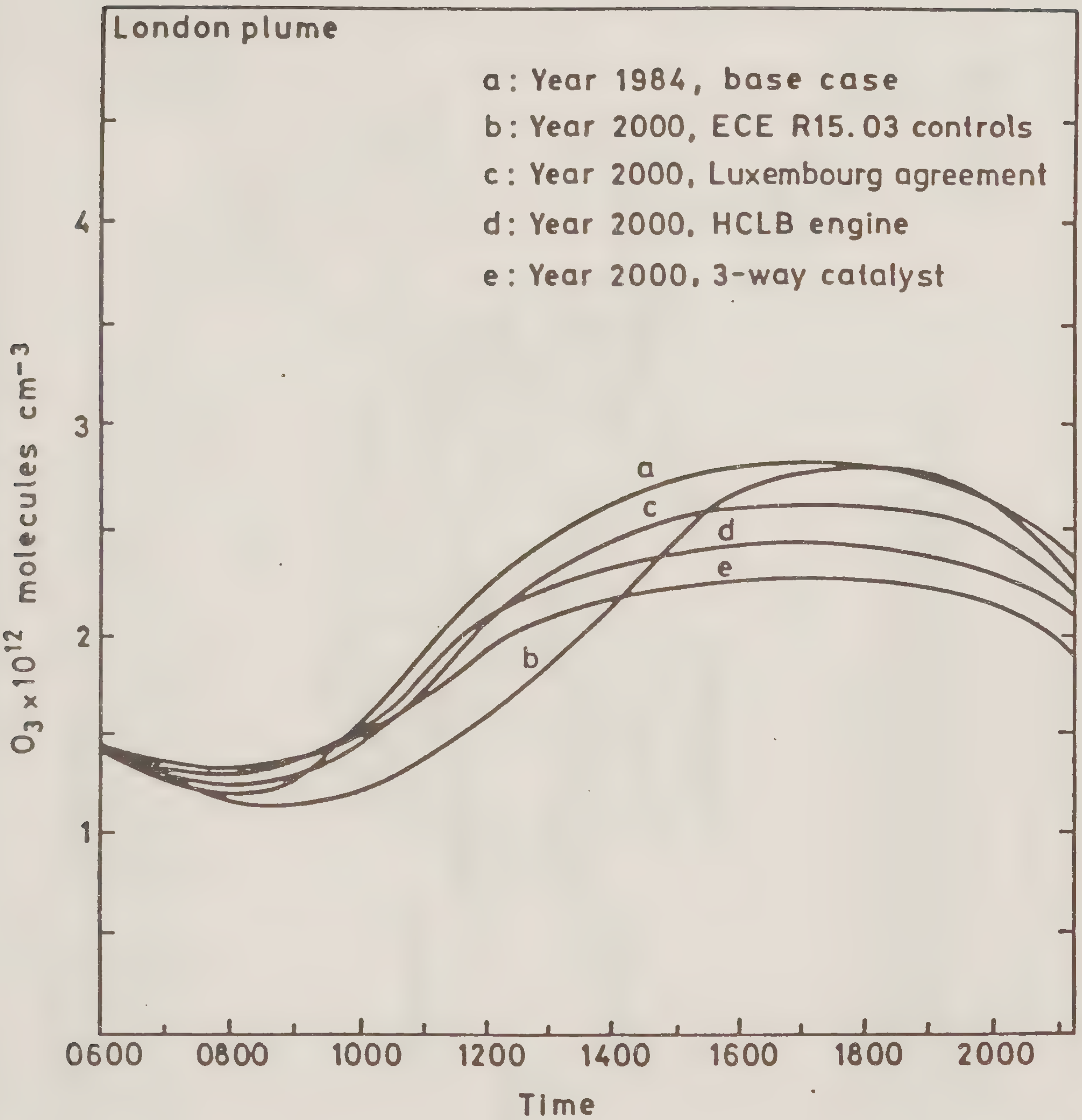

FIG 3 Calculations of effects of various controls for traffic emissions in the year 2000 (Hough, Harwell)

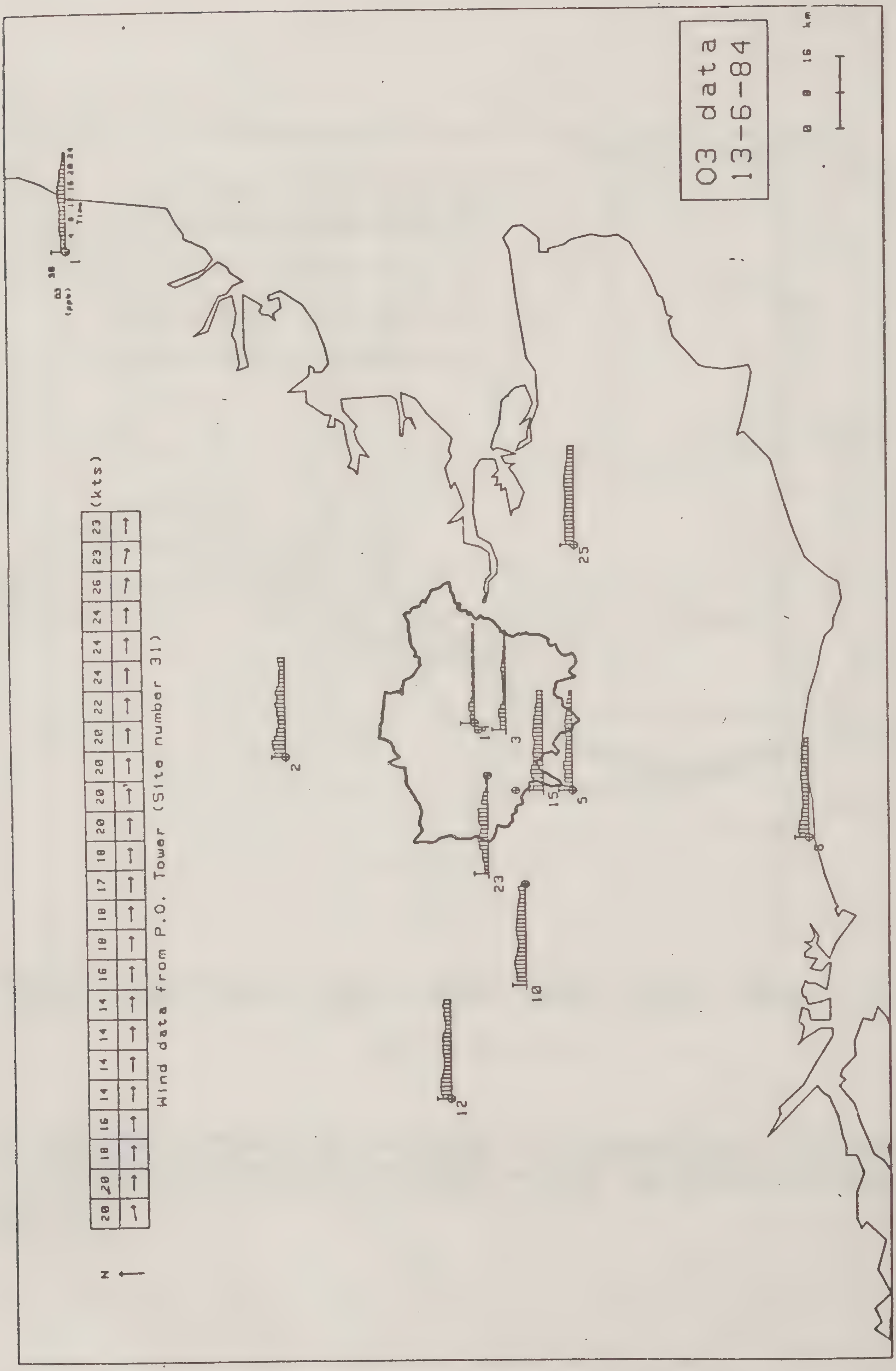

FIG 4 London survey measurements of ozone

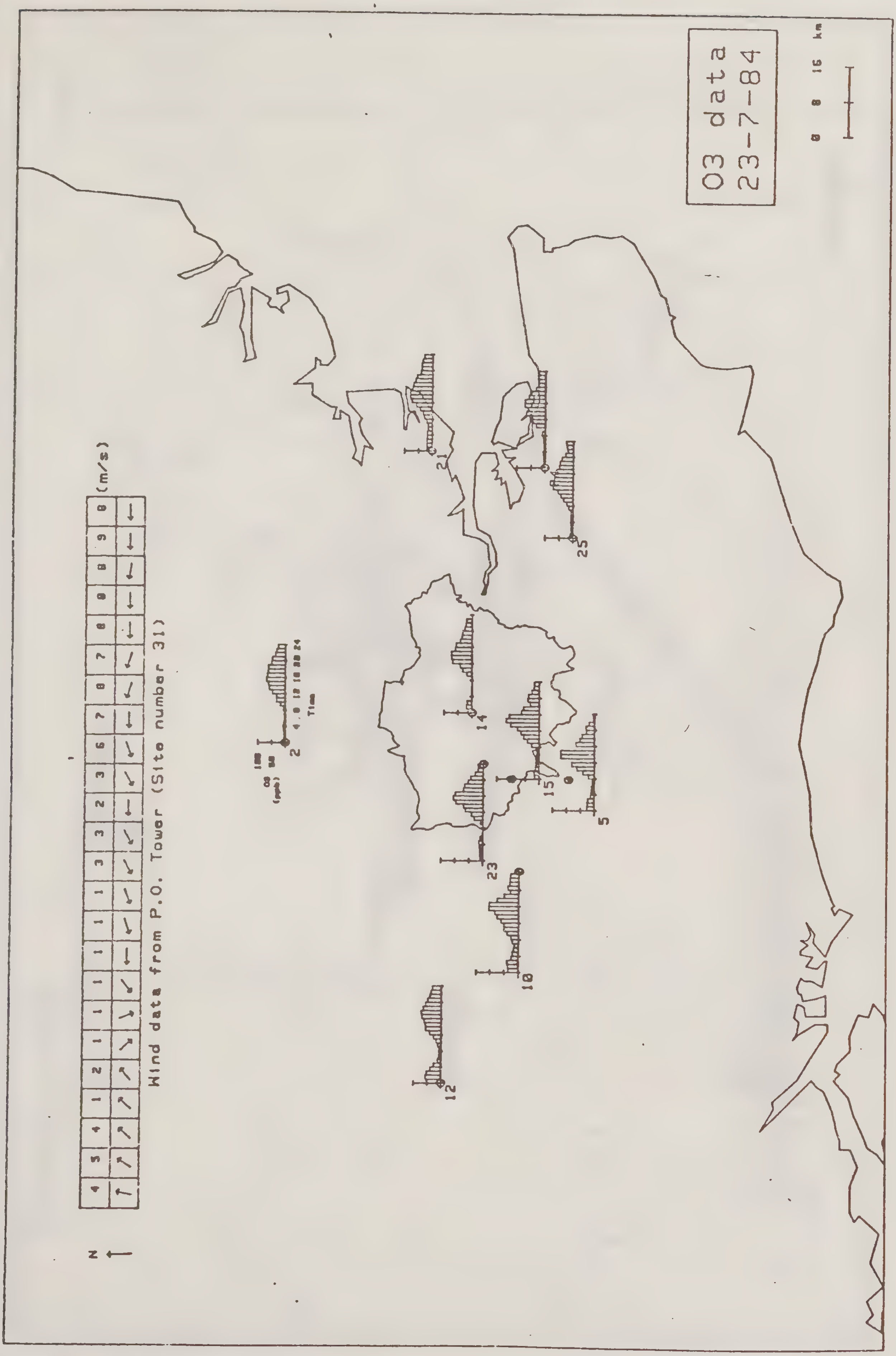

FIG 5 London survey measurements of ozone

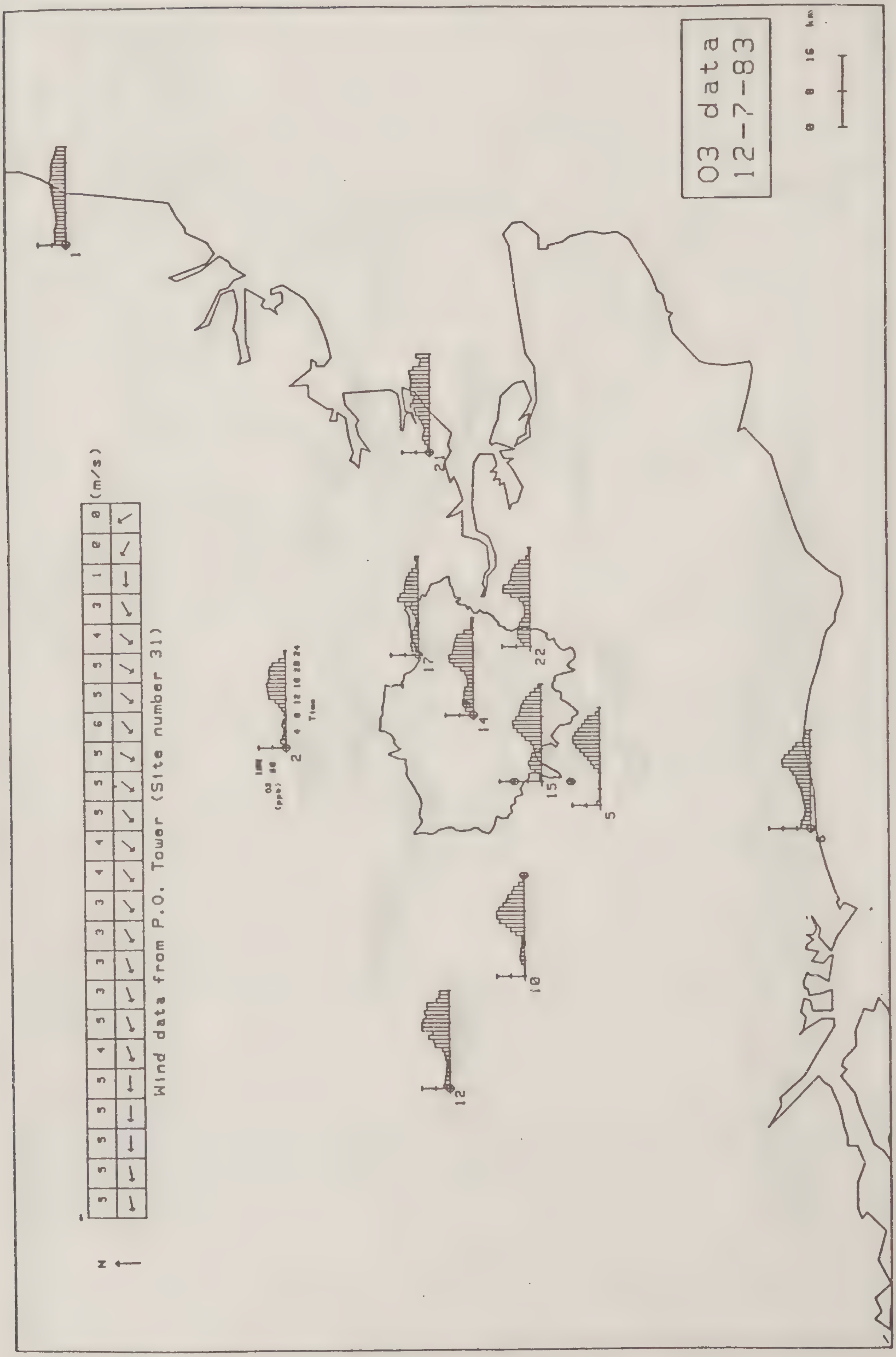

FIG 6 London survey measurements of ozone

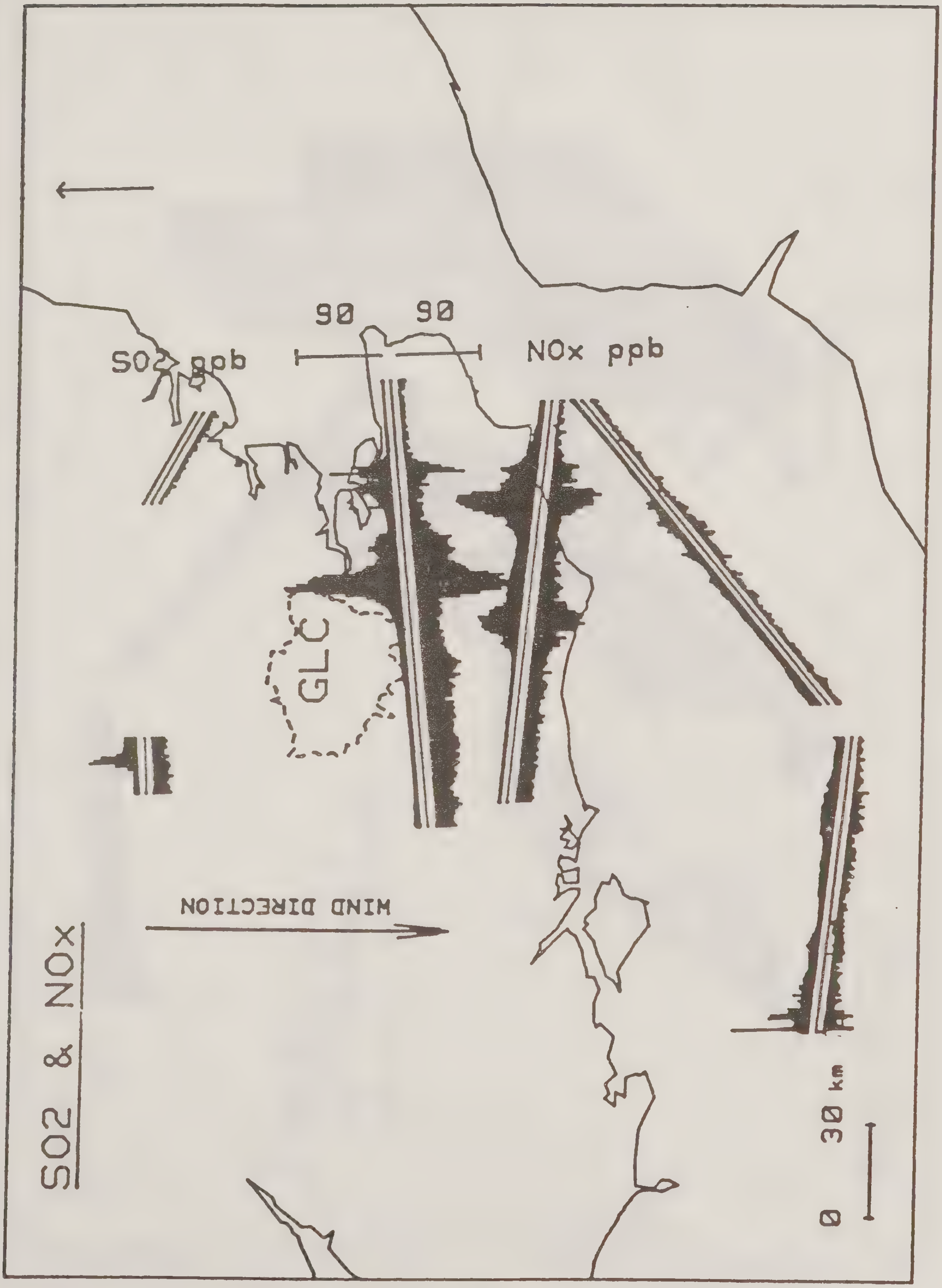

FIG 7 Aircraft data for 12-7-83

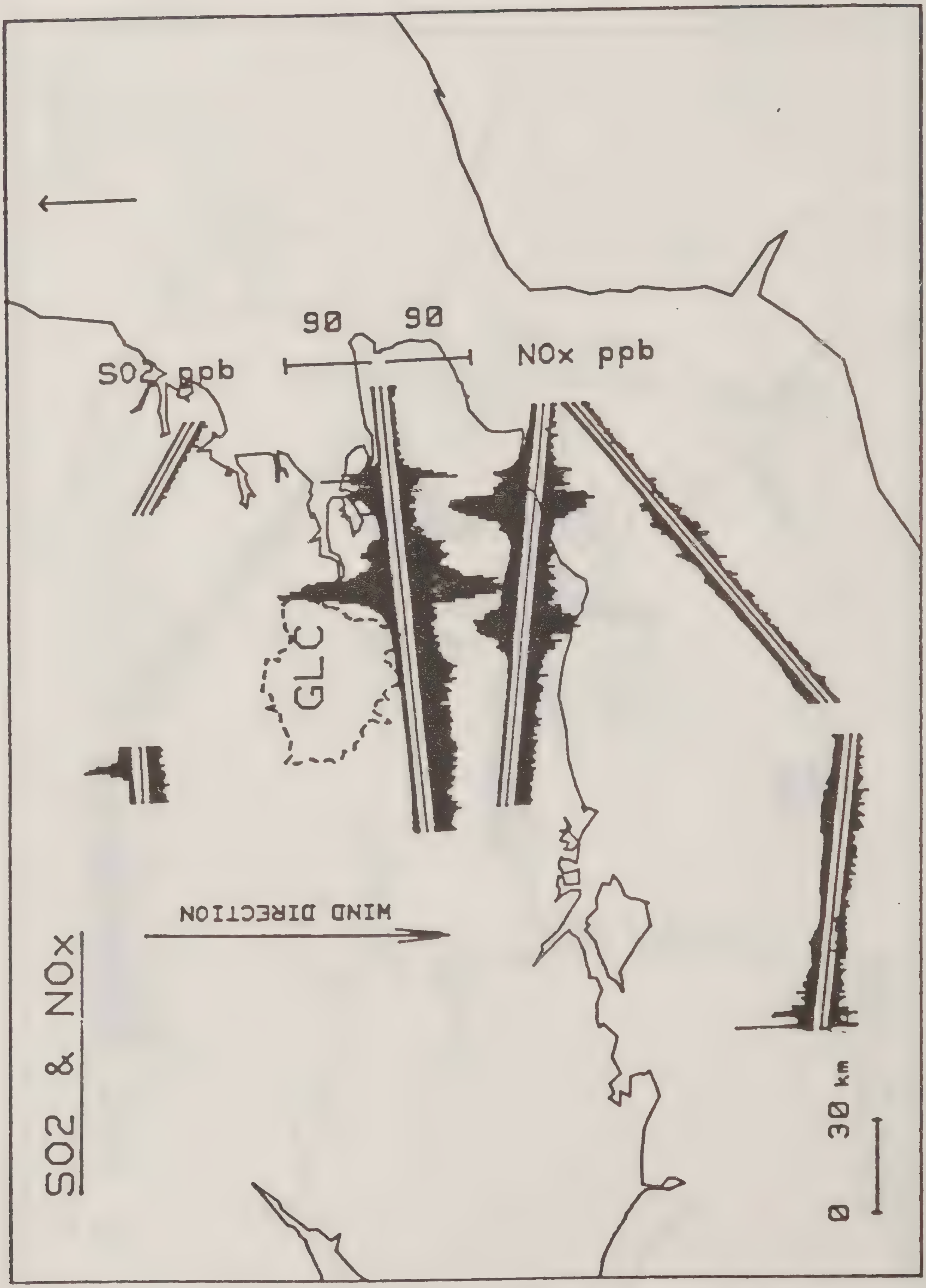

FIG 8 Aircraft data for 12-7-83

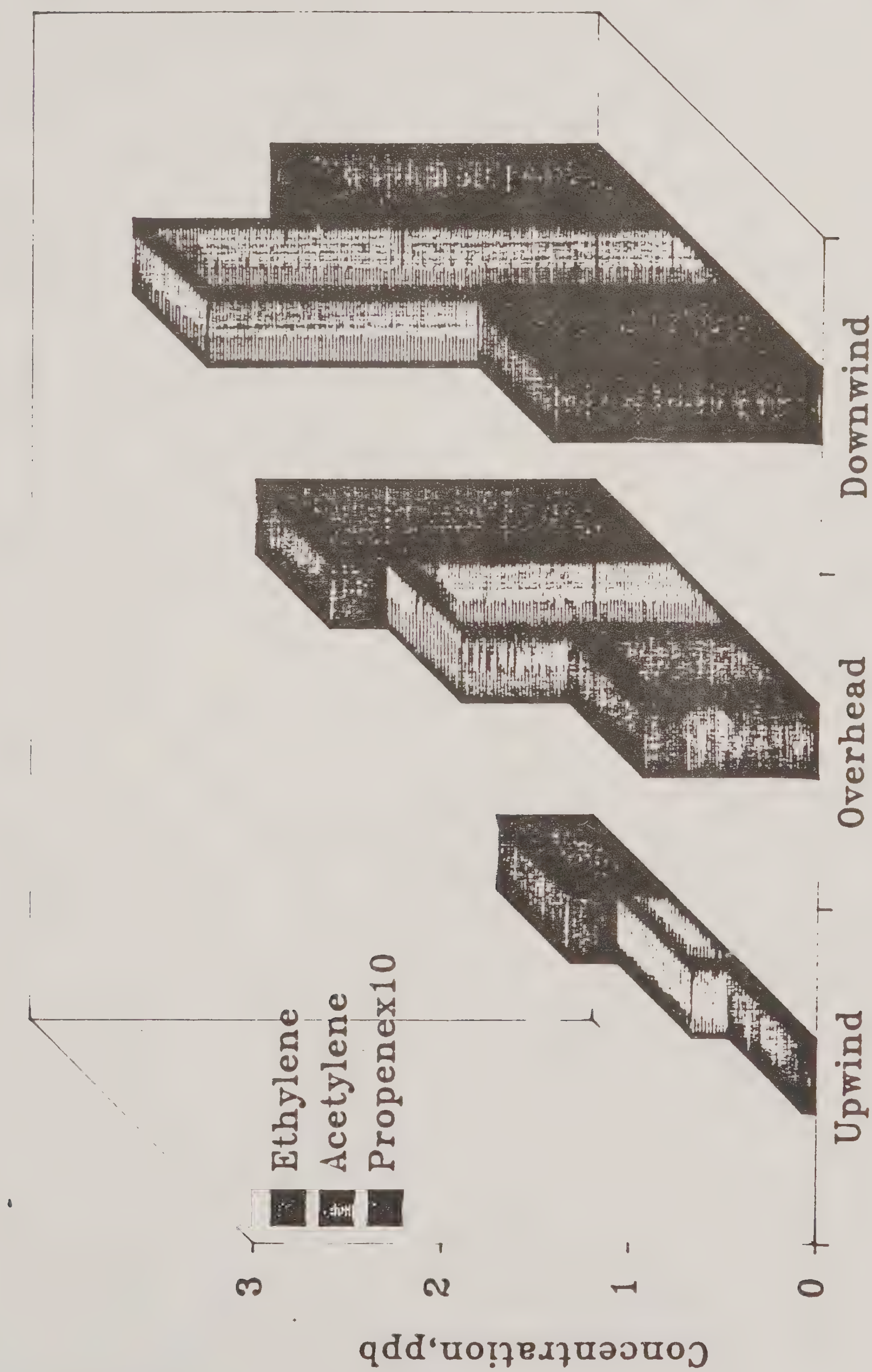

FIG 9 Aircraft data for 12-7-83

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26 – 29 OCTOBER 1987
BRIGHTON

54th CONFERENCE PROCEEDINGS

NATIONAL SOCIETY FOR CLEAN AIR
136 NORTH STREET
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ENGLAND

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54th ANNUAL CONFERENCE
26 - 29 OCTOBER 1987
BRIGHTON

PRESIDENTIAL ADDRESS
By
The Rt. Hon. The Lord Nathan

NATIONAL SOCIETY FOR CLEAN AIR
136 North Street - Brighton BN1 1RG

Let me say first that it is a great honour to hold the office of President of this Society, which has over so many years been in the forefront of environmental concern and action. Its membership largely consists of practitioners of environmental control and regulation and it is a good corrective for a person such as myself to be associated with the leading, indeed I think one of the only such Societies in this country, as a good contrast to the somewhat remote atmosphere of the Royal Commission of which I have been a member for so many years and also for that reason the membership of the Select Committee in the House of Lords. It is awfully easy to become disassociated from reality in these ethereal spheres and this Society, I hope, will bring me down to earth and keep me firmly there.

And this brings me to Councillor Poole, my predecessor, who has given me some wise advice already and I look forward to further wise advice in the coming year. He, of course, has been in the forefront of practising, as a Councillor, the art of controlling pollution and his long service to the Society lends distinction both to the Society and to himself and I count it a great honour to have been elected President having none of those qualifications and as I said this afternoon I shall do my best to serve the Society as it should be served. It is, of course, also an honour to hold the office in succession to so many distinguished predecessors, some of whom are old friends, for whom I have the highest admiration. I am thinking of Lord Ezra, who was Chairman of the Coal Board and did so much to improve the environment, particularly by seeing to the landscaping of slag heaps, which desecrated the countryside. And then there was David Williams, now happily also a Vice President, who is President of Woolfson College Cambridge and the next Vice Chancellor, who in service on so many commissions and committees, in addition to his writings as a leading authority on administrative law, has done so much to advance modes of thought on environmental matters. And

then, rather further back in time, there was Lord Flowers, whom I have had the privilege of knowing well over the years, a former Chairman of the Royal Commission and currently Vice Chancellor of London.

Now the badge with which I was invested today bears the portrait of Evelyn who wrote, in the seventeenth century, a tract upon the pollution by smoke of London and who, as I understand, devised a form of stove for burning coal somewhat similar, and perhaps equally effective, to that now adopted in smokeless zones. So he was a man in advance of his time and I am proud to wear this badge, not only for the fact that it signifies my Presidency of the Society but also because it bears the protrait of Evelyn. I myself was concerned if you like with historical pollution in London, because many years ago I was Master of one of the City Guilds, the Gardeners Company, and part of our uniform was, and is still, to carry a bouquet of sweet smelling herbs to keep off all offensive and noxious odours. You may note that we still carry them.

Now, in accordance with custom, I am charged with giving this Presidential Address and I must start by confessing to failure to live up to the high standards set by the Society and I refer to noise. I have at home these past eleven days been without electricity on the mains but, against that possibility, years ago I acquired a small generator. I may say it has been used every year during cuts but never, of course, as seriously as this year. And serious it has been, with no light or hot water or central heating and the deep freeze warming up. So each morning first thing, in the dark and cold, I go outside to start her up and when, on the third pull she comes to life with a roar of a hundred decibels, I am overcome with joy and relief and when I return in the evening and hear them echoing still, calm and satisfaction come over me but a silent greeting one can cut with a knife. It's full of foreboding, irreparable breakdown, no petrol, a desolate evening in view.

Now I first become concerned in environmental matters as Chairman of a working party, formed in 1973, on energy and the environment. It was on that working party that I first met Admiral Sharp, whom I am so delighted to see here this

evening, who was then Secretary General of this Society and who now glories in the magnificent title of Emeritus Director General of the international sister organisation. There were many members who became friends and who have remained so since, amongst them Robin Grove White, who is to speak later in this conference. It was a remarkable experience, because we came into being just before the oil crisis broke in 1974 and, in the face of the oil crisis, decided we must report with the utmost speed, which we did in June of 1974. Working together under that sort of pressure makes a community of those who have not previously met and that was what happened in this case. It may interest you to know that Fritz Schumaker, the author of "Small is Beautiful", was one of them. One of the recommendations we made in that report was that there should be a Standing Commission on energy and the environment and, in the fullness of time, the Commission on Energy and the Environment was formed under the chairmanship of Lord Flowers. It produced a monumental report on Coal and the Environment. The day after publication the Commission was put into abeyance, that is it was killed off. It is rare, from my experience, that one serves on a committee whose recommendations are put into effect in one's liftime. It is, I think, unique to find a recommendation has been implemented and disimplemented in so short a time.

The key factor, which emerged from our working party and which was adopted by Lord Flowers' Committee as the cornerstone of their Report, was that a policy for the development of resources must be created in the context of its environmental and social consequences and that protection of the environment cannot be separated from the other objects of a policy for energy. Skirmishes between environmental interests and energy interests benefit neither side. Over the past ten years or more integration of industrial and environmental policy has been a guiding principle. Many of our leading industrialists are environmentalists. Therefore, I particularly regret that Greenpeace, which has so much to offer and which has achieved so much over the years, should have embarked on confrontation and violent conflict with the marine incineration vessel, Carlos II, recently in the North Sea.

Such action today is likely rather to produce a backlash against environmental interests than to promote them.

I learnt a lot from undertaking that first study in 1973. I learnt much too from our study of lead which resulted in the Ninth Report of the Royal Commission. You may remember that some years ago there was much worry about the effect of lead on young children. There were fears that lead in air affected the central nervous system and intelligence. The Lowther Committee found no cogent evidence of this. And then CLEAR, a brilliantly led pressure group, raised public anxiety and that is why the Royal Commission undertook the study of lead in the environment urgently. It had not previously had it in mind to do a separate study of lead. It was due to that pressure group that it decided to do so. CLEAR compaigned to eliminate lead from petrol The Royal Commission agreed with the Lowther Committee that there was no cogent evidence of lead in air causing the suggested damage to small children. What we did find was that, in the case of lead, this was rapidly accumulating in the environment and that the burden of lead in the environment was becoming far too heavy and the accumulation should be reduced; secondly the margin of safety, that is the difference between actual levels of lead in air and those known to cause damage, was far too narrow and far narrower than for other toxic substances; and thirdly that substantial improvement could be achieved quickly and without great economic cost by eliminating lead from petrol. And we so recommended at 2.30 p.m. one day and at 3.30 p.m. that same day the Government accepted that recommendation, surely a record to be compared with the seven years that elapsed between our recommendation about air pollution and acceptance of that recommendation by government.

The experience shows that pressure group well led can produce results. Pressure groups do not consist, as some would have us believe, of cranks with little else to do and holding weird ideas about exotic plants and rare insects. Generally the members are ordinary people who join from bewilderment and fear. Bewilderment about the impact of new products, the new found dangers of familar things and the speed of change and fear of the resultant dangers and

that those in authority do not know what they are about. That is why, when novel products and new concepts come forward, which hold promise of enormous benefits, those benefits and the risks and dangers associated with them must be examined openly with full public participation. Scientific data and assessments must be publicly available for examination, probing and testing. If regulations and proceedings for the use of these novel products are proposed, these must be acceptable and they will only be acceptable if full information is available. A current instance of such a case is the release to the environment of genetically engineered micro organisms. The benefits could be enormous and the risks too and so I hope there will be full debate and examination and that the Royal Commission's current study will make a contribution to that study. It is not good enough, nor is it acceptable, for those in authority to pursue the line "we know best".

I turn finally to two subjects which have vexed and intrigued me over the years to which one day I hope solutions will be found and adopted. There was a product tanker of some 1800 tons which collided off Selsey Bill only a few miles from here. The cargo tanks were not ruptured and she capsized with virtually no oil spilt. The state of wind, sea and tide made it dangerous to life to try and transfer the cargo. Any spillage would have affected severely fishery, ecological and amenity interests at Selsey Bill itself, where inshore are the nursery grounds for much of the sole found in the Channel, Pagham, Chichester and Langstone Harbours which are conservation centres, particularly as bird sanctuaries and, of course, popular beaches in the area. And so she was towed inverted as she was to a nearby safe haven. It was this experience which brought to mind that, had a serious oil or chemical spill taken place off Selsey Bill, areas enjoyed by a great number and variety of people, who came specifically to vist them, as well indeed as those who live there would have been severely damaged. Very wide repurcussions would result from the damage to the ecosystem. Such losses will rarely be quantifiable in terms of money yet there is no doubt that loss would have been suffered by the community. It seemed to me then, and it seems to me now, wrong that when the community suffers this kind of damage it should be without the right to

compensation. It's extraodinary that when the ecosystem upon which all life depends is destroyed there may be no remedy, whereas for the loss of a ship or a house or something made by man, which can easily be replaced, there is no difficulty. A fisherman may be able to obtain compensation for damage to his fishing net but not be able to do so for destruction of the fishing grounds from which he derives his livelihood. This surely is a problem which should be addressed and maybe it could be addressed by the European Community by directive. I believe this should be done effectively and I much hope it will be.

The methods of regulating environmental pollution have inevitably been central to my experience, both as a member of the Royal Commission and as Chairman of the House of Lords Select Committee Sub Committee concerned with the environment. It has always struck me as extraordinary that pollution of air, water and land are not only regulated differently but according to different principles with different objectives. Indeed the language as well as the acronyms for each are different. Speaking to this distinguished and expert audience it would not be appropriate that I should go into the details of air pollution control in respect of scheduled processes - it's the last thing I should wish to do or you either - and the application of best practicable means and the functions of the Inspectorate, originally the Alkali Inspectorate now Her Majestys Inspectorate of Pollution. I stress, however, that a key factor in these arrangements is that the Inspectorate concerns itself with the plant and its operation with a view to reducing emissions and rendering them harmless - wastes disposed of to air. Now it is proposed, and there will be delay in implementation, and this seems entirely sensible that the range of scheduled processes be somewhat extended and that these new ones be dealt with similarly but by Local Authorities, in practice by their officers, the Environmental Health Officers. With the great strides in quality and qualifications which Environmental Health Officers have achieved in recent years I believe this should work well. It has the additional advantage that pollution is by and large a local matter and it is right that the pollution authority concerned with its control should be the elected Local Authority. It is only in very special cases, where very

unusual qualifications are required, that it seems to me that a national inspectorate with those special qualifications is appropriate. But how strange it is that there are no such controls in relation to wastes destined for disposal to land. With increasing shortage of convenient land build sites and opposition to land fill, both on principle and in accordance with the "Nimby" syndrome - "not in my backyard" - the trend towards incineration evident on the Continent and in the United States is likely to develop. The central approach to pollution control, demarcation between pollution of land, air and water and the application of different principles and practices to each is surely no longer acceptable. The range of scheduled processes is confined to those producing especially difficult emissions to air. I place before you for consideration an extension of scheduled proceeses to those produceing especially difficult discharges to water and wastes destined for disposal to land. It is ironic that the Inspectorate can and does intervene with plant and its operation in special cases of scheduled processes to minimise air pollution but special wastes arise without any control. The control is only to their disposal. The creation earlier this year of the unified Pollution Inspecorate should surely provide the spur to action on these developments.

This Society has an enviable record of achievement. It has created and fostered new ideas, new approaches to problems as they develop and new solutions and by quiet persistence has them adopted. This is not a Society whose annual conference can be described as others have been as a rest home for the chronically articulate. I believe that this conference which starts now will be a great success. I hope it will be widely reported. The subjects under discussion are matters of widespread public concern and those leading the discussions are pre-eminent in their fields. I am sure that in the coming week we shall have a most interesting time.

nsca

54th ANNUAL CONFERENCE
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ACID DEPOSITION: THE ROYAL SOCIETY STUDY

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INTRODUCTION

Since the SWAP objectives were first formulated in 1983 new understanding has developed. The first part of this introduction is intended to set the SWAP objectives in the context of current perspectives.

Surface waters toxic to fish arise when water bearing the anions of strong acids flow through acidic soils. Such soils are characterised by a depletion of neutralising capacity and by a related increase in soluble aluminium species. The latter are mobilised into surface waters in toxic forms by strong acids, predominantly sulphuric acid of mad-made origin. The acidic state of the soil could be the result of natural acidification processes or acid deposition or both.

The timescale on which all these processes have been taking place has been notably clarified by recent studies of diatom remains in lake sediments. Within the SWAP programme, this technique has been refined and extended and has clearly demonstrated the progressive acidification of lakes in Norway, Sweden and Scotland, from about 1850 to 1970. The fall in pH is paralleled in the cores by evidence of industrial activity in the form of metallic and carbonaceous particles. In a few lakes changes in the diatom population since about 1975 provide a first, tentative indication that the fall in pH may have been reversed.

This work convincingly demonstrates the connection between man-made sulphur emissions and surface water acidification over more than a century. It leaves open the question of adverse changes in soil acidity over this period. To answer this question and the related question of the response of soils and surface water to reductions in acid deposition, it is necessary to develop dynamic models of the hydrology, chemistry and biology of catchments and to acquire the appropriate input data.

Mathematical modelling of complex dynamic systems may be used to improve the design of experiments on the system, the analysis and interpretation of experimental results, and the understanding of the interactions in the system. The use

of models may also help in predicting the consequences of changes in the input to the system. Two models with basically similar structure have been applied to observations and experimental series from SWAP catchment studies. One model tries to mimic the dynamic behaviour of a catchment in time periods lasting from a few days to a few years. The present version of this model, when calibrated for each catchment, is able to reproduce the main features of the observed streamwater chemistry over a wide range of conditions. The good performance of the model confirms its underlying assumption that the strong acid anions (SO^{2-}, Cl^-, NO^-)*(see paper) act as vehicles for cation transport causing acid (H^+) outflow if there are few other cations available. The other model tries to mimic the dynamic behaviour of a catchment in time periods from a few years to many decades. It has not yet been sufficiently explored and validated, but it has achieved some success in reproducing the historical development of the acidification of lakes in southernmost Norway, in Galloway, Scotland and elsewhere.

Comprehensive data sets are now being obtained from several carefully chosen sites in Norway, Sweden and Scotland differing in topography, geology, soil composition and vegetation and receiving very different levels of acidic deposition. Strongly acidified, pristine and intermediate sites have been comprehensively instrumented to aid simultaneous investigations of acid inputs, hydrology and stream flow, soil structure and composition, soil and soil-water chemistry and stream chemistry and stream biology.

This integrated approach, involving close collaboration between many different disciplines and institutions within the three countries, is producing a large flow of experimental data some preliminary results of which are described later under the individual programme objectives. An important feature of the experimental design has been the adoption of common methods of analytical quality control and of standard protocols and procedures that should greatly facilitate comparison and interpretation of the data from the different sites.

From the outset the strategy has been to build upon and supplement other relevant research programmes within the

three countries. This has resulted not only in more efficient use of resources but a degree of collaboration, coordination and common understanding that could hardly have been achieved without the SWAP initiative involving the three Academies.

The conclusions of this report are based on the papers presented at the conference. These presentations and the discussions were informed by international work in this field.

OBJECTIVE 1

> In the affected areas of Norway and Sweden, what are the factors, in addition to pH, that in practice determine the fishery status of lakes?

Observations from field sites and from well-designed laboratory experiments indicate stongly that concentrations of calcium and monomeric inorganic aluminium together with pH are the most important chemical factors in determining the fishery status of lakes and streams. Acid streams can usually support a trout population if the calcium concentrations are sufficiently high. In waters containing organic acids some of the aluminium is fixed in organic complexes which are much less toxic to fish.

The responses of fish to changes in water chemistry depend on the species, age, size and maturity. Salmonid populations fail to survive if the pH stays for long below 5.2, the concentration of monomeric inorganic aluminium exceeds 50ug/l and the calcium concentration falls below 1mg/l. During periods of high stream flow, induced by storms or snow melt, the acid and aluminium concentrations rise sharply while the calcium concentration falls. These episodic changes often result in large fish kills or reduce the ability of fish to withstand later stress. For example, salmon smolts may survive exposure to enhanced acidity and aluminium and appear healthy although their fitness has been impaired so that they die when they migrate into sea water. The effect of acidity and aluminium combined is greater than that of acidity alone.

These solutions are toxic because they impair the ability of the fish to maintain the salt content of their body fluids against the inevitable loss in fresh water. In particular, they appear to reduce the activity of enzymes that control the uptake of sodium by the gills leading eventually to circulatory failure.

Once the lakes and streams have become acidic, considerable changes may occur in the composition of the whole ecosystem. Invertebrate populations, an important part of the fish food chain, are reduced. Some crustaces are killed by the combined action of acidity and aluminium affecting their salt-balance while certain benthic invertebrates, such as mayflies, are killed by acidity and also may suffer by the acid water killing the algae and bacteria that affect their food supply. Mosses and fungal mats often develop and modify the exchange of nutrients between the sediments and the lake water. The mosses may serve as reservoirs for aluminium that cen be mobilised if pH is reduced, as in a storm or snow melt episode.

At the practical level, although the toxic action of monomeric inorganic aluminium, the low toxicity of organically complexed aluminium and the protective effect of calcium ions are not fully understood, it now appears possible to characterize the basic fishery status of lakes and streams in terms of the concentrations of inorganic aluminium, calcium and pH but the characterization and toxicity of acidic episodes requires further investigation.

OBJECTIVE 2

> What are the biological, chemical and hydrogeological characteristics of catchments which determine whether the composition of surface waters falls within a range acceptable to fish?

The biological, chemical and hydrogeological characteristics of catchments which determine whether the composition of surface waters fall within the range acceptable to fish are those which have an influence on the input of acidity, the liberation of monomeric inorganic aluminium species, calcium and heavy metals. As indicated earlier, fish death occurs in

surface waters at pH < 5.2: Ca^{2+} < $1.0 mgl^{-1}$ and inorganic monomeric Al > $50 ugl^{-1}$. Repeated episodic events over short periods of time may eventually be as lethal as prolonged exposure at lower levels.

The major terrestrial biological components are trees and other natural vegetation. The major aquatic biological components are stream and lake bed organisms e.g. mosses and algae. The overall effect of trees which scour acid deposition from the atmosphere is to increase acidic input. Stream bed organisms and the stream beds themselves may act as sinks for aluminium hydroxides washed out from the soil, but may be significant souces of bioavailable aluminium when acidic episodes occur.

The major chemical components to be considered are the aluminium and base cations (Ca^{2+} and Mg^{2+}) in the soils of the catchments. The aqueous chemistry of aluminium is very complex, but it is deduced that it is the low molecular weight (monomeric) aluminium hydroxides that are the most toxic species to fish. Calcium and magnesium provide the chief acid neutralising capacity (base saturation) of the soils but, in addition, the calcium content of the surface water must be maintained > $1.0 mgl^{-1}$ for physiological reasons if fish are to survive particularly in the presence of aluminium levels c.$50 mgl^{-1}$. The aluminium originates from minerals in the soil, especially from the clay factions, and is released by H^+ ions copartnered by SO^{2-}(*see paper) or other mobile anions. In this respect, soils derived from acidic rocks such as granite with their high aluminosilicate levels, relative high toxic heavy metal contents and low alkaline earth levels, are particularly prone to the release of aluminium and provide only low base cation exchange capacity. Soils derived from intermediate or basic/ultrabasic rocks will be less troublesome as will soils derived from sedimentary rocks, particularly limestones.

The hydrogeological characteristics that are most important, apart from the provenance of the soil mentioned above, are those that control water pathways through the various materials that make up the soil profile. Dramatic increases in stream water acidity are commonly associated with peak flow occasions (episodes). Water leaving the soil may have a

variety of histories depending particularly on whether the soil is saturated or not. It has been established that even when the soil is saturated, e.g. at snow melt, most of the discharge is generally water that has been stored in the catchment since before the event. Irrespective of where the water has been stored it is likely to have been affected by contact with upper acidic soils before emerging. This may result in pulses, which, whilst they may not liberate much aluminium from the soil, may release monomeric inorganic aluminium species from the stream or lake bed as shown by experiments on direct acidification of streams. This aspect may be particularly important where surface flow occurs over bare rock or where there is a relatively large contribution of direct acidic precipitation on the surface of the lake itself.

OBJECTIVE 3

> In Norway and Sweden, to what extent are the biological, chemical and hydrogeological characteristics of catchments, which determine whether the water quality is acceptable to fish, being adversely affected by the acid deposition itself?

Distinctive chemical and hydrogeological changes have been documented for catchments associated with acidic waters. The palaeoecological studies now indicate the water acidification at the recent rate and the present geographical scale has occurred only since the industrial revolution, especially since 1950, and that the natural spread of spruce some 3000 years ago did not cause changes in the soil that resulted in the acidification of adjacent water lakes.

A number of soil studies repeated over periods of several decades, have shown that an underlying increase in soil acidity (as distinct from surface water acidity) can most reasonably be explained by two main factors: namely increased man-made sulphur deposition and increased forest cover (which itself also enhances the rate of sulphate input). Studies, using strontium isotope and other techniques, have assessed natural weathering rates. These and other studies have shown that man-made anthropogenic sulphur deposition

plays a major role in the loss of base cations from the soil.

When soil acidification and base depletion reach a critical level (around pH 4.5) aluminium, which has been deposited in large amounts in various chemical forms as a weathering product in the soil, may become soluble in the monomeric inorganic form. In the presence of anions of strong acids some aluminium species start to move in water out of the soil. Sulphate ions of industrial origin now constitute an important part of the anion content in the soil water in southern Scandinavia and thus play a major role in the transport of aluminium toxic to fish from soils to freshwater systems. These effects have been measured in assocation with natural episodes of greatly increased waterflow and have been generated experimentally by acidifying a catchment.

It is established that atmospheric deposition of nitrogen compounds has increased in recent decades. So far this has not been shown to be an important factor in water acidification, probably because the forest ecosystem still retains the main part of the incoming nitrogen. There is no clear evidence of other effects of acidic deposition on the biological characteristics of catchments leading to adverse effects on the water quality for fish.

OBJECTIVE 4

> What changes would be brought about in water chemistry and fishery status in Norway and Sweden by given levels of reduction of man-made sulphur deposition?

The relationship between deposition of sulphur compounds and water acidification is now established, though other factors play a role in some areas. Reduced deposition is therefore necessary if water quality is to be improved for fish. Although the extent and rate of recovery cannot yet be satisfactorily predicted, some progress has been made through several programmes which have given consistent, if incomplete, indications.

Regional surveys have shown that water acidification is

generally confined to areas receiving acid deposition. Palaeoecological evidence for the historical decrease in the pH of many lakes and for a possible, recent incipient reversal of this trend has been reported in the introduction. There are also indications from direct measurements in a few sensitive lakes of a slight rise in pH since acid emissions began to fall.

Likewise the application of deacidified precipitation to covered catchments (c. 600 sq meters), at Risdalsheia in Southern Norway, has resulted in a considerable reduction of nitrate and sulphate in run-off compared with that from adjacent, control plots. The increase in pH compared with the controls is, however, small.

Some indication of the possible course of recovery following a reduction in acid precipitation has been given by the two mathematical models which, also, have been described in the introduction. Both models predict a slow change in the soil but more rapid changes in water chemistry. However, the results are very tentative since some important input parameters (e.g. rates of weathering and of biological uptake of ions and the kinetics of the soil sulphur) are not at present well known and possible changes in the soil organic matter are even more difficult to estimate.

Several approaches are possible to predicting changes in fishery status in relation to changing levels of atmospheric deposition. Extensive many-lake surveys are establishing the approximate limits of a 'benign envelope' for fish survival in Norway bounded by the intercorrelated factors of pH and inorganic aluminium concentration and of Ca^{2+} concentration. The correlative relationships involved are generally supported by laboratory controlled-factor experiments and by field responses during acid episodes. However there are uncertainties associated with episodic impacts.

Overall it is clear that, although promising beginnings have been made, we are much further from providing an adequate response to Objective 4 than is the case for the other three.

CONCLUSION

The Surface Water Acidification Programme (SWAP) has succeeded in bringing together scientists from Norway, Sweden and the UK to achieve an outstanding degree of international cooperation and coordination. The Management Group considers that the commitment of the three Academies has been crucial to this success. The programme, by augmenting and integrating existing studies, is achieving much greater progress than could otherwise have been obtained.

Consequently, as the above report makes clear, the work reviewed at the conference has disposed of a number of issues and uncertainties, particularly in relation to objectives 1, 2 and 3. The Group envisages that with some additional resources the Programme will have adequately achieved these three objectives by late 1989.

The major remaining challenge is objective 4, particularly in respect of the rate of improvement of water quality in relation to the rate of reductions in deposition. This depends on the reversibility of the acidification process, the size and nature of sulphur reservoirs in the soil and the extent of recovery possible without soil restoration. If this objective is to be satisfactorily secured, it seems clear that further research will be required.

It will be the task of the next meeting of the Management Group to formulate two recommendations: first on the additional work and resources necessary to satisfactorily conclude the Programme with respect to objectives 1, 2 and 3; second on the follow-up research now seen to be necessary to address objective 4 and on appropriate mechanisms for its implementation, possibly in the form of a new programme.

SURFACE WATER ACIDIFACTION CONFERENCE BERGEN 1987

PAPERS PRESENTED:

The SWAP research in relation to its objectives
Sir John Mason

Long range transport of air pollution over Europe: methods of calculation and some results from EMEP
Dr. A. Eliassen

Description and instrumentation of SWAP field sites in Britian
Sir John Mason

Norwegian SWAP sites: description and review of field studies
Professor H. Seip

Experimental treatment of catchments with elemental sulphur and sodiumsulphate
Dr. H. Hultberg

The Hoylandet project
Dr. E. Dahl

Hydrochemical response in the Allt a'Mharcaidh
Drs. A. Jenkins, P.G. Whitehead and A. Whitcomb

Processes and products of mineral weathering in soils of the SWAP catchments in Scotland and Norway
Drs. A. Mellor and M.J. Wilson

Chemical weathering rates at the RAIN catchments in Norway
Drs. R.F. Wright and T. Frogner

Calcium budgets for catchments as interpreted by strontium isotopes
Drs. G. Jacks and G. Aberg

Determination of average historical weathering rate in conjunction with Project RAIN
Prof. E. Lotse

Studies of chemical weathering by laboratory batch experiments and lysimeter investigations
Dr. U. Lundstrom

Activities at the Nordmoen Field Station of interest for SWAP weathering studies
Dr. A.O. Stuanes and Prof. P. Jorgensen

Long-term translocation of Fe and Al in Soil and run-off water
Drs. M.T. Olsson and P. Melkerud

Strong acid and organic acid in the run-off from peat and woodland
Professor O. Westling

Episodic changes in water chemistry - effects on fish and invertebrates
Dr. A. Henriksen et al.

The distribution of sensitive surface waters in Scotland
Drs. D.E. Wells and R. Harriman

Aluminium speciation in natural waters using 'in site' hollow fibre fractionation
Dr. B. Salbu

Organically complexed aluminium in natural acid waters; measurement and prediction
Dr. E. Tipping

Strong and weak acids speciation in soil, ground and stream waters in forest catchments after treatment with S-powder and Na_2SO_4
Dr. Ying Hua Lee

Examples of changes in water chemistry during lake acidification and de-acidification
Drs. C. Forsberg and G. Morling

Some recent observations on regional water chemistry, fish and aquatic animals from lakes and streams in the Hoylandet area
Dr. I.P. Muniz

Stream chemistry and salmon survival in the Allt a'Mharcaidh, Scotland
Dr. R. Harriman et al.

Effect of low pH and aluminium on migrating salmon
Professor W.T.W. Potts

The physiological basis of acid resistance in aquatic insect larva
Dr. I.D. Twitchen

Acidified water: effects on physiological mechanisms in the gills of salmonids
Drs. O.B. Reite and M. Stuanes

The effects of short episodic changes of pH and aluminium on sodium balance and respiration in brown trout
Drs. R. Morris and J. Reader

Aluminium impact on mortality of lotic mayfly nymphs at low pH
Dr. J. Hermann

Trophic relationships in acid waters: invertebrates, algae and acid sensitivity of certain bacteria
Dr. J.G. Jones et al.

The United Kingdom Paleolimnology Programme
Dr. R. Battarbee

Mechanisms and processes important for the biotic
structure in acidified lakes
Drs. U.P. Andersson et al.

The Paleolimnology Programme - Norway and Sweden
Dr. I. Renberg

Ecological consequances of acidification of surface
waters - mechanisms acting through food availability
and physiological constraints
Drs. J. Hermann and P. Sjostrom

Acidity of surface water in Norway
Prof. I.T. Rosenqvist

Methods for pH calibration and reconstruction
from paleolimnoligical data
Dr. H.J.B. Birks

Development of the diatom flora in Tveita
Fiskelos-tjern, Agdar, S. Norway
Bjorg Stabell

Pollen-analysis research in Tveita Fiskelos, Bygland,
S. Norway
Dr. H. Hoeg

Recent changes in the acidity of two SWAP study lakes
in S. Norway
Dr. F. Berge

Have changes in land use influenced the regional
lake acidification?
Dr. J.A. Timberlid

Magnetic and radiometric studies of sediments and peat
Professor F. Oldfield et. al.

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AIR POLLUTION CONTROL
THE CHANGING EUROPEAN SCENE

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Four years ago, in the summer of 1983, air pollution control in Europe was almost exclusively the prerogative of national governments. Prospects for radical change seemed slight. Yet within the space of just 11 months the foundations had been laid for a series of international agreements which effectively changed the face of European environmental policy. Now, in 1987, the impact of some of these measures can be seen; in other areas negotiations are still continuing, emphasising the intractable nature of the problems. But while the outcome of these negotiations remains uncertain, it is already clear that air pollution will remain a central issue on the European agenda for the foreseeable future. More than that, the shift in the focus of air quality policy-making away from national governments and towards supranational organisations seems set to continue, circumscribing the jurisdiction of the traditional control authorities still further.

European air pollution control fora

By far the most important European supranational authority in the field of air pollution control is the European Community (EC). Now comprising 12 Member States (1), the EC is administered by four separate bodies:

- the Commission (the initiator of policy and the executive arm of the administration)
- the Parliament (watchdog, adviser to the Commission on policy proposals and empowered to reject EC budgets)
- The Council of Ministers (the decision-making body)
- the Court of Justice (responsible for ensuring that the implementation of the treaties is in accordance with rule of law).

One of the more remarkable features of EC policy-making is the fact that a comprehensive body of environmental legislation should have been introduced over the past 15

years on the basis of a treaty in which the word 'environment' does not even appear. Environmental protection measures have been introduced largely within the scope of Articles 100 (on the harmonisation of laws affecting the internal market) and 235 (providing general powers), relying on a generous, if not unanimous, reading of these provisions. Much of this legal uncertainty has now been cleared away, however. Since 1 July 1987, amendments to the original Treaty of Rome - known as the Single European Act - have provided special powers for the introduction of environmental legislation. A series of objectives and principles for EC environmental policy are laid down in the new Article 130R (2), while Article 100A, which introduces supplementary powers concerning the establishment and functioning of the internal market, specifically refers to environmental protection as an area in which legislation may be introduced. Its significance for the future of EC environmental policy is that, whereas proposals issued under Article 130R require a unanimous vote in the Council of Ministers, Article 100A measures may be adopted on the basis of a qualified majority.(3) This rule has already been applied in order to secure a majority decision on new vehicle emission standards (see below).

The majority of EC environmental legislation appears in the form of 'directives' - an instrument which is binding as to the result to be achieved (such as a certain air quality), but leaves to each Member State the choice of form and methods (such as legally binding air quality standards). This element of flexibility makes the directive the most appropriate general purpose instrument of EC policy, accommodating the various legislative and administrative traditions of the Member States.

The second forum of importance for air pollution control in Europe is the UN Economic Commission for Europe (ECE). Established in 1947 with the objective of improving economic relations and other forms of cooperation, it now has 34 members, comprising the European members of the UN plus Switzerland, the US and Canada. (4) Among its many subsidiary bodies is a group known as the Senior Advisers to ECE Governments on Environmental Problems, which considers the broad policy aspects of environmental issues.

It provides governments with the opportunity to share their experience and to consult on environmental policy proposals, and thereby acts as the main focus for ECE's environmental activities. To support this work the organisation compiles comprehensive statistical information and analyses - one of its most useful functions.

A short history of European air pollution control measures (5)

Although, strictly speaking, not the earliest European measure relating to air pollution, the 1973 EC Environment Action Programme (6) represented the first specific political commitment to tackle a broad range of environmental problems at the supranational level. It was nevertheless notable for the absence of explicit proposals for specific control measures, focusing instead on broad principles, areas of concern and a framework for action. Subsequent Action Programmes have, however, become increasingly substantive. The second programme of 1977 (7) was essentially an elaboration of the 1972 document, designating several air pollutants (such as sulphur dioxide, smoke, lead and nitrogen dioxide) as candidates for quality objectives and setting out a number of other general action areas. With the third programme of 1982, (8) the aim of establishing air quality objectives was reiterated. The problems of acid rain and long-range transboundary pollution were specifically noted as matters of serious concern, and the introduction of measures to reduce polluting emissions from motor vehicles and the combustion of coal was foreseen.

In the new fourth Action Programme, (9) agreed by the Council of Ministers in May 1987 and covering the period 1987-1992, five main goals for air pollution control are set:

- to identify pollutants (both outdoor and indoor)
- to determine the most appropriate focus for control instruments (the pollutants themselves or the source of the pollution)
- to set and implement EC-wide objectives for substantial emission reductions to combat acid deposition and forest die-back
- in the longer term, to reduce ambient air concentrations of pollutants to level acceptable for

sensitive ecosystems
- to develop appropriate management techniques (such as pollution modelling, monitoring networks and economic control instruments).

In addition, the possibility is raised of setting EC emission standards for installations burning fuel oil and solid fuels, and air quality standards for photo-chemical oxidants.

Alongside these broad programmes of action, a body of EC and ECE legislation and agreements has been progressively built up over a period of nearly two decades, focusing on three main areas:
- product standards for fuels and vehicles
- air quality standards
- industrial plant emissions.

The earliest measures, agreed first as ECE regulations and subsequently translated into binding EC directives, concerned the emission of certain pollutants from motor vehicles. Beginning with emission standards for carbon monoxide and unburnt hydrocarbons from petrol-engined vehicles in 1969, the limits have been progressively tightened and extended to include nitrogen oxides and to regulate the opacity of diesel-engine emissions.(10) The EC directives, although binding on the Member States, are so-called 'optional' legislation. That is to say, Member States are not obliged to adopt the standards but they may not refuse type approval if a vehicle meets the requirements, reflecting the role of free trade considerations in the introduction of these measures. The prevention of barriers to trade was also an important stimulus to the introduction of product standards for fuels, regulating the lead and benzene content of petrol (11) and the sulphur content of gas oil.(12)

In contrast to the long-established practice of laying down common product standards, the introduction of European air quality standards has a much shorter history. The first substantive measure dates from 1980 when the EC directive on air quality limit values and guide values for sulphur dioxide and suspended particulates was agreed.(13) This laid down a series of interrelated ground-level limit values for the two pollutants, though in the context of the current

debate on acid deposition these standards are by no means onerous. Two years later a similar directive was introduced regulating ambient concentrations of lead,(14) and in 1985 a directive on atmospheric concentrations of nitrogen dioxide was added to the list.(15) It must be noted, however, that the limit values laid down in these two latter measures are not so strict as to require a significant general reduction in emissions.

As in the case of vehicle pollution, it was the ECE which first tackled the issue of industrial plant emissions. On the initiative of the Nordic countries, and reflecting a contemporary concern to improve East-West cooperation, a convention on long-range transbounday air pollution was proposed. This was to be signed by all European states plus the US and Canada. In the event the Scandinavian proposals for a 'standstill' clause and national commitments to reductions in sulphur dioxide emissions of up to 50 per cent were relaxed to a general obligation to reduce and prevent air pollution, encouraging 35 states to sign the agreement - known as the Geneva Convention - in November 1979.(16) The 24 ratifications needed to bring the convention into force were secured by 1983.

As finally formulated, the convention was primarily a symbolic measure. It nevertheless acted as the vehicle for a far more substantive agreement - the so-called '30% Club'. The Nordic countries persisted in lobbying for a substantial reduction in acid emissions, focusing their efforts on sulphur dioxide. Although a proposal for an across-the-board cut in 1983 emissions of 30 per cent by 1993 was rejected by the Executive Body of the Geneva Convention, 10 countries who supported such an approach signed their own agreement in 1984 (using 1980 rather than 1983 as the baseline).(17) Through this commitment the group of signatory countries became known as the 30% Club. A year later, however, support for the measure had grown and proved to be broad enough to allow a protocol to be drawn up within the framework of the Geneva Convention. Called the Helsinki Protocol, it was immediately signed by 21 states.(18)

While these developments were unfolding, the European Commission was drawing up its own response to the threat

of acidification. This emerged in 1983 as a proposal to introduce common Community-wide controls on industrial plants. In its final form as agreed in 1984, the directive (19) provided a broad regulatory framework requiring new plants in specified categories to be given prior authorisation, to adopt the best available technology not entailing excessive costs and to ensure that certain emissions do not cause significant air pollution. Existing plants are required gradually to adopt the best available technology. It also empowers the Council of Ministers to fix emission standards for the various types of plant at a later date.

Current developments

It is air pollution issues which have proved to be the most intractable problems on the European environmental agenda over the past four years, and current developments suggest that this dissension is likely to continue for the foreseeable future. Two separately negotiated but related sets of measures are at the heart of these long-running disputes - proposals on acid emissions reductions and vehicle emission controls.

Acid emissions

Acid rain is an issue which refuses to go away. In fact, since 1983, when Western European countries have belatedly accepted the Scandinavian claim of acidification damage, research data have mostly indicated a deteriorating situation. A few examples may illustrate the new concern:

- at the First International Conference on Acidification,held in May 1986,(20) researchers from 21 countries generally agreed that the damage caused by acid rain was greater than previously thought. It was reported, for instance, that in Europe a total forest area of 6 million hectares had been damaged by acidification and that agricuture was suffering annual production losses of £3 billion.
- the conclusions of research carried out by Scandinavian scientists under the aegis of the Nordic Council of Ministers and presented to the

International Conference on Air Pollution in 1986, (21) indicate that it will be necessary to reduce sulphur deposition to 2-5 kg/ha/year in order to ensure the long-term protection of forest soils and surface water. Current rates of deposition are around 40 kg/ha/year in Western Europe, and present policies are likely to halve this by the year 2010. The results of the study were broadly accepted by parliamentarians from 18 European countries at the conference.

- in the latest Forestry Commission survey of forest health (22) it was concluded that Britain has a higher proportion of slightly or moderately damaged conifers than West Germany, indicating a marked worsening over the 1985 figures. Moreover, after many years of expressing scepticism over the role of air pollution in damage to European forests, the Commission now acknowledges that airborne pollutants are a major contributory factor in poor tree growth, and accepts the multiple stress hypothesis for forest decline on the continent, whereby air pollution plays a key role in weakening trees.(23)

The European negotiations on new control measures currently centre on two pollutants. Most attention is focused on sulphur dioxide, the subject of the Helsinki Protocol. No new nations have become members of the 30% Club since the protocol was signed in 1985, leaving five Western European countries outside the agreement: the UK, Ireland, Spain, Portugal and Greece. The UK's argument for not becoming a signatory country differs from the reasoning followed by the other four states, where industrial development is at a relatively low level and would be seriously impeded by such a commitment. From the British point of view, the protocol takes no account of emission reductions prior to 1980; taking 1970 as a baseline, for example, would show UK sulphur dioxide emission reductions in a much more favourable light. A 30 per cent reduction on 1980 emissions, it is argued, imposes a disproportionately heavy burden on the UK. It must be noted, however, that even on this basis, the Federal Republic of Germany, Belgium and the Netherlands are all committed to greater

reductions than the UK. (In fact, the UK has not actually made a definite commitment to a specific minimum reduction in sulphur dioxide emissions. With the decision of September 1986 to retrofit 6000 MW of existing CEGB generating capacity with flue-gas desulphurisation equipment between 1988 and 1997, a maximum reduction of 44 per cent on 1970 emissions seems likely - equivalent to a 27 per cent cut on 1980 emissions. But the reduction will be less if the stations involved burn coal with a sulphur content of less than 2 per cent or if they should be downgraded on the CEGB's 'merit order'.)

This controversy has continued into negotiations on the proposed EC directive on emissions from large combustion plants. Issued in December 1983, (24) the measure has still to be agreed after three years of negotiations. The main thrust of the original draft was to secure substantial reductions in the 1980 emissions from all existing large combustion plants (above 50 MW) by 1995 - 60 per cent in the case of sulphur dioxide and 40 per cent for both nitroge oxides and particulates. In practice most of the plants in question are power stations, though many cement works, brickworks and ore-roasting plants would be included. New large combustion plants would have to meet strict new emission standards. For the UK, the directive as drafted would probably require flue-gas desulphurisation equipment to be fitted to 12 stations at a total cost of about £2 billion (including additional investment to replace lost generating capacity).

It soon became clear that the proposal as it stood would not be agreed. Although Germany, France, Belgium, the Netherlands and Denmark gave varying degrees of support, the UK together with Italy, Ireland, Spain, Portugal, Greece and Luxembourg were broadly opposed to the measure. The deadlock eventually led to a revised proposal in 1986 involving a 'three-speed' approach: Germany, France, Belgium, the Netherlands and Denmark would reduce sulphur dioxide emissions by 50 per cent or more by 1995, the UK and Italy by 40 per cent, and the remaining Member States by 10 per cent (Spain) or maintain them at their 1980 levels. Together, these commitments would result in a 45 per cent reduction for the Community as a whole. But this proposal

also foundered, both because some parties (Germany and the European Commission) felt that it did not go far enough and because others (including the UK) insisted that it went too far. This broad approach does seem to have been generally accepted, however, though the possibility remains that the differences will remain too great to be bridged.

In a further development, calculated to increase pressure on the recalcitrant Member States, the European Commission proposed in February 1987 that the Community itself should become a party to the Helsinki Protocol.(25) This would require a commitment to reduce sulphur dioxide emissions from the 12 Member States taken as a whole by 30 per cent between 1980 and 1993. Calculations by the Commission indicate that existing commitments and plans by the Member States would enable the Community to meet this goal.

Nitrogen oxides provide the second focus for discussions on further measures to control acid emissions. Again, action has been initiated by both the European Commission and the ECE. As noted above, EC negotiations are being pursued in the context of the draft directive on large combustion plants, where a reduction of 40 per cent in 1980 emissions from these installations by 1995 has been proposed. Because of the controversy surrounding cuts in sulphur dioxide emissions, the negotiations on nitrogen oxides have been relegated to the background. Objections were nevertheless raised by some Member States (including the UK) to the uniform 40 per cent reduction, and in 1986 it was agreed in principle that a flexible approach similar to that proposed for sulphur dioxide should be formulated. Detailed negotiations on allocating the reductions between the Member States are awaiting the results of a UK-initiated study on the extent to which nitrogen oxide emissions can be cut by modifications to combustion systems. If substantial reductions can be achieved, agreement might be reached on emission targets which could be met by retrofitting low-NOx burners, rather than requiring more expensive abatement equipment such as selective catalytic reduction. Most Member States nevertheless favour an overall cut of 40 per cent in emissions from all plants with a capacity greater than 50 MW.

In a parallel set of negotiations being undertaken under the auspices of the ECE, attempts are being made to draw up a nitrogen oxides protocol to the Geneva Convention. Broad agreement seems to have been reached to apply the 'best available technology which is economically feasible' to new stationary and mobile sources of nitrogen oxides. Specific reduction targets might be laid down after 1993 based on the levels of nitrogen deposition which ecosystems can tolerate in the long term (estimated at 10-20 kg/ha/year, compared with present rates of 30-40 kg/ha/year in much of Europe (26)). The question of emissions from existing plants remains unresolved, however. A group of nations, including Germany, France and the Scandinavian countries, would prefer to see a uniform reduction in emissions to be achieved by a fixed date. The alternative proposal, favoured strongly by the UK, is only to require the retrofitting of low-NOx burners to existing combustion plant. It is a pattern with a familiar ring to it.

Vehicle emissions

On 20 June 1983 the West German government announced that it would ban leaded petrol from 1 January 1986 and at the same time introduce measures which would require the fitting of catalytic converters to all new cars. This single announcement effectively triggered a fierce debate throughout the EC on the whole subject of vehicle emissions, a debate which is still continuing in late 1987. The problem of motor vehicle pollution is not simply a question of deciding on suitable standards for exhaust emissions. At issue are also the principle of the free internal market (unilateral measures would lead to the closure of a national market to motor vehicles from other Member States), whether lead should be banned from petrol (strict emission standards require the fitting of catalytic converters, which are 'poisoned' by lead) and the disproportionate effects of measures on national motor industries (the motor industries of the UK, France and Italy produce a high proportion of smaller cars for which emission controls are relatively more expensive).

At the time of the German initiative the European Commission was already working on vehicle emission control

proposals, but the political turmoil generated by the announcement had its effect in Brussels. A year later, when the Commission's proposals were published, (27) it became clear that Germany's plans had been taken into account. The key requirements of the new measures were the introduction of unleaded petrol in all Member States by 1 July 1989 (though Member States may do this from 1 January 1986) and the reduction of non-lead emissions from vehicles in two stages - the first stage taking effect from 1 October 1989 for new models and 1 October 1991 for all new vehicles, and the second stage from 1 October 1995 for all new vehicles.

The proposal to introduce unleaded petrol, having the twin objective of reducing airborne lead concentrations, was agreed without undue resistance, though the target date was deferred from 1 July to 1 October 1989.(28) But the controversy surrounding vehicle emission reductions was such that the measure absorbed most of the negotiating time at three successive Council meetings before an outline agreement received majority support in June 1985. The two major obstacles to the adoption of the compromise formula then and over the succeeding two years were Greece's demand for EC funds to help tackle Athens' chronic air pollution problem and Denmark's insistence that the proposals were simply not strict enough for smaller vehicles.

With the coming into effect of the Single European Act on 1 July 1987, however, the simple expedient of reissuing the proposal under Article 100A allowed a decision to be taken on the basis of a qualified majority. This was done at a special Council meeting held on 21 July 1987: Denmark and Greece were duly outvoted and the directive was adopted. As it stands, the measure will require vehicles with an engine capacity of 2 litres or more to be fitted with a three-way catalytic converter from 1988/89; those with engines in the 1.4-2 litre range with a lean-burn engine plus the simpler oxidation catalyst from 1991/93; and smaller vehicles with a lean-burn engine only from 1990/91. Stricter stage-two standards for the smaller cars to take effect from 1992/93 are still to be agreed, however.

It must be added that the vote of 21 July may well result in

a test case for EC environmental policy-making under the new Single European Act. The specially convened meeting was, in fact, called by Denmark itself as President of the Council of Ministers from 1 July to 31 December 1987. By forcing a vote, Denmark is hoping to exploit two contingency provisions of EC procedures. First, the measures agreed by the Council have to be laid before the European Parliament for approval. There is known to be a substantial body of opinion in the Parliament which favours more stringent limits. If a majority should demand amendments to the directive, the Commission will be obliged to submit new proposals to the Council of Ministers. But whether a qualified majority will be found within the Council for greater emission reductions is very doubtful. If the revisions are not approved, the directive will have to go back to the Commission for further amendment. The second course of action, which Denmark itself can initiate, is to invoke a provision in the Single European Act which allows a Member State to take stricter action than that laid down in EC legislation on the grounds of environmental need. Denmark might therefore introduce national vehicle emission standards which are stricter than those laid down in the new directive and thereby ban the sale of vehicles, including those manufactured in other Member States, which do not meet these limits. Should this be done, a test case in the Court of Justice would be inevitable, brought either by the European Commission or by one or more of the affected Member States, and the four-year-old dispute would be guaranteed a new lease of life.

Conclusions

The lessons to be drawn from the recent history of air pollution policy-making in Europe are many:

- that the setting of an overall environmental protection objective involves complex political trade-offs, though this process is not, as many commentators maintain, invariably governed by the 'Convoy Principle' where the slowest ship dictates the pace for all;
- that the allocation of each country's contribution towards achieving that overall objective causes

intractable problems where a substantial asymmetry exists in the distribution of the costs and benefits attached to a particular policy;

- that international negotiations might well be facilitated by basing the design of policy proposals on more sophisticated and relevant notions than uniform emission reductions;
- that the political importance attached to common product standards and the internal market has enabled a large number of European agreements to be reached on the limitation of vehicle emissions.

But above all, the events of the past four years have ensured that the formulation of policy to tackle the major air pollution issues is now a European, rather than purely a national, responsibility. All the signs are that this is an irrevocable shift, shortly to be reinforced by a series of new proposals relating to such topics as emission standards for industrial plants, new air quality standards, controls on ammonia emissions and production limits on chlorofluorocarbons. The implications for national practices are profound, affecting such fundamental control instruments as best practicable means and the authorisation of industrial processes. In short, air pollution control will never be the same again.

References and footnotes

(1) Since 1 January 1986 the 12 Member States are Belgium, Denmark, Federal Republic of Germany, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain and the United Kingdom.

(2) The objectives of environmental policy are:

- the protection and improvement of the quality of the environment
- the protection of human health
- the prudent and rational use of natural resources.

The principles of environmental policy are:

- prevention
- control of pollution at the source
- integration of environmental protection requirements

into other Community policies
- the 'polluter pays principle'.

(3) The adoption of a proposal by qualified majority requires at lest 54 of the 76 available votes. These votes are distributed among the Member States on the basis of population size as follows:

- Germany, France, Italy, UK: 10 votes each
- Spain: 8 votes
- Belgium, Greece, the Netherlands, Portugal: 5 votes each
- Denmark, Ireland: 3 votes each
- Luxembourg: 2 votes.

(4) The 34 members are Albania, Austria, Belgium, Bulgaria, Byelorussian SSR, Canada, Cyprus, Czechoslovakia, Denmark, Finland, France, German Democratic Republic, Federal Republic of Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Turkey, Ukrainian SSR, USSR, United Kingdom, USA and Yugoslavia.

(5) For a comprehensive review of EC environmental policy and legislation see Nigel Haigh, EEC Environmental Policy and Britain, London, Longman, 1987.

(6) OJ C112 20.12.73.

(7) OJ C134 13.6.77.

(8) OJ C46 17.2.83.

(9) OJ C3 7.1.87.

(10) Directive 70/220/EEC (OJ L76 6.4.70), based on ECE Regulation No 15 (ECE (General) Document W/TRANS/WP 29/293/Rev.1. 11.4.69) and as amended by Directives 74/290/EEC (OJ L159 15.6.74), 77/102/EEC (OJ L32 3.2.77), 78/665/EEC (OJ L223 14.8.78), and 83/351/EEC (OJ L197 20.7.83). Diesel engine emissions are regulated by Directives 72/306/EEC (OJ L190 20.8.72) and 77/537/EEC (OJ L220 29.8.77).

(11) Directives 78/611/EEC (OJ L197 22.7.78) and 85/210/EEC (OJ L96 3.4.85).

(12) Directives 75/716/EEC (OJ L307 27.11.75) and 87/219/EEC (OJ L91 3.4.87).

(13) Directive 80/779/EEC (OJ L229 30.8.80)

(14) Directive 82/884/EEC (OJ L378 31.12.82).

(15) Directive 85/203/EEC (OJ L87 27.3.85).

(16) Convention on Long-Range Transboundary Air Pollution, Geneva, 13.11.79.

(17) The original members of the 30% Club were Austria, Canada, Denmark, Finland, France, Federal Republic of Germany, the Netherlands, Norway, Sweden, Switzerland.

(18) The 21 signatory states are the 10 original members of the 30% Club plus Belgium, Bulgaria, Byelorussian SSR, Czechoslovakia, German Democratic Republic, Hungary, Italy, Liechtenstein, Luxembourg, Ukrainian SSR, USSR.

(19) Directive 84/360/EEC (OJ L188 16.7.84).

(20) First International Conference on Acidification, Amsterdam, 5-9 May 1986.

(21) International Conference on Air Pollution, Stockholm, 8-10 September 1986.

(22) Forestry Commission, Forest Health and Air Pollution: 1986 Survey, R & D Paper 150, Farnham, Forestry Commission, 1987.

(23) Forestry Commission, Air Pollution and Forestry. Bulletin 70, London, HMSO, 1987.

(24) OJ C49 21.2.84.

(25) COM (87) 67.

(26) Results of the project Critical Loads for Sulphur and Nitrogen presented to the International Conference on Air Pollution, Stockholm, 8-10 September 1986.

(27) OJ C178 6.7.84.

(28) Directive 85/210/EEC (OJ L96 3.4.85).

Appendix

Proposals of the European Commission relating to air pollution and awaiting decision

1. Emissions from large combustion plants (OJ C49 21.2.84)

2. Vehicle emissions (OJ C178 6.7.84)

3. Smoke from diesel engines (OJ C174 12.7.86)

4. Emissions from diesel-powered commercial vehicles (OJ C193 31.7.86)

5. Chlorofluorocarbons (COM (86) 602)

6. Speed limits (COM (86) 735)

7. Becoming a party to the Helsinki Protocol (COM (87) 67)

8. Banning regular leaded petrol (OJ C90 4.4.87)

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54th ANNUAL CONFERENCE
26 – 29 OCTOBER 1987
BRIGHTON

UK CLEAN AIR LEGISLATION PROPOSALS

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INTRODUCTION

Many of you will recall that when Dr. Martin Holdgate gave the opening address to last year's conference at Blackpool, in place of the Minister, Lord Skelmersdale, he started by setting out what was likely to be in the Government's long-awaited Consultation Paper on Air Pollution. Your conference then went on to discuss the issue at your first morning session.

The paper itself then, when it was issued in December 1986, held few surprises. People have told me that perhaps the biggest surprise was that it did come out by the date promised by Dr. Holdgate - Christmas 1986! Indeed, when the Minister promised that date at another congress last autumn - that of the Institution of Environmental Health Officers - he was asked to clarify which Christmas he meant. But if the paper - when it did appear - contained few surprises, it did have the merit that it gained general support.

I want to go on in the main part of my paper to set out in some detail what the response was to each of the main proposals. But let me start by telling you that of the 191 responses received on the main thrust of our proposals, there was very considerable support from all sides - local authority associations, industry and environmental groups - for the new regime that was proposed.
Anyone wanting to examine the responses to the consultation paper will find in the Libraries of the House of Commons and of the Department of the Environment (or the Scottish Development Department or the Welsh Office as appropriate) copies of those 59 respondents for which explicit permission for access was given. I might say that neither your Society nor originally the Campaign for the Freedom of Information gave such explicit permission in their substantial response.

But I am glad to say that the Campaign for Freedom of Information and this Society have done so. The Department is therefore reviewing its procedures to ensure that the open access policy is carried out in the most effective way possible.

HMIP/BPEO

Before I go to talk about the implementation of our proposals, I want to refer to a major change in the administration of pollution controls. Her Majesty's Inspectorate of Pollution was formed within DOE on 1 April this year. It incoporated the Inspectorate with which many of you will have been most familiar - the Industrial Air Pollution Inspectorate - as well as the Radiochemical Inspectorate and the Hazardous Waste Inspectorate, and took on a new role in the control of water pollution. The new Inspectorate is charged with taking a multi-media approach to the control of discharges in England and Wales - whether to air, water or landfill. It will develop methods for determining the best practicable environmental options for dealing with industrial processes and the wastes which result from them.

Many of you will known that in its forthcoming 12th report, the Royal Commission on Environmental Pollution are looking further at the concept of BPEO (best practicable environmental option). The development of this new multi-media approach to minimising pollution is one that we are obviously closely concerned with in Air Quality Division. So if I concentrate today on the ways of improving air pollution control, I hope you will not misunderstand what Air Quality Division in DOE is up to. We are, with colleagues who have responsibility for other media, moving towards fully integrated control. But as the first step we need to resolve what has to be done to improve the control of emissions to air - remembering that these developments must not compromise future options for BPEO.

NEXT STEPS

So, accepting the future implications for BPEO, where do we go from here?

It is clear from the Queen's Speech that there will be no primary legislation this session. So we cannot implement all the consultation paper proposals in a Green Bill this year. Ministers have therefore decided to begin to implement some of the proposals by Regulation. We hope these can be laid in the Spring. Essentially, what we are planning is to extend the current 1983 schedule of industrial processes controlled by the Inspectorates to cover those that were proposed in the consultation paper to come under their control. Most significantly, this means municipal waste incinerators. We are also considering bringing the glass industry temporarily under the Inspectorate's control so that all the categories specifically listed in the European Commission's "Framework Directive" to combat air pollution from industrial sources will be covered.

We will also bring in changes to the Inspectorate's system of registering works and start trials of the new publicly-accessible authorisation system that will give better information about the control requirements and operational performance of scheduled processes. This will allow us to test out the system administratively before it is brought in by statute for all Parts A and B processes.

We have now begun the process of discussing the details of our proposals with local authority associations and industry groups, and your Society. We plan to hold further discussions next month and I have just written inviting this Society and other interested groups to these discussions.

It might be helpful if I now set out in more detail precisely how out thinking has developed on each of the main topics raised in the consultation paper, in the light of the responses we received.

BPM

Firstly BPM. There was overwelming support (88 to 8) for the proposals to retain the BPM concept that has been at the heart of air pollution control for more than a century. But many people queried what weight should be given to financial considerations, believing that this could be an

obstacle to improving air quality. Others wanted more weight given to environmental aspects. We are looking therefore at whether there is a need to clarify the concept, keeping of course a close watch on the development of the BPEO idea.

LOCAL AUTHORITY POWERS

Many of you will be particularly interested in our plans to give local authorities new powers of prior control over part B processes that mirror those already available to the Inspectorates. This proposal was met with a little more opposition - 74 for, 13 against. The major concern was about the possible inconsistency of enforcement around the country. We believe that this can be minimised by the proposals for the issue of national guidance and the right of appeal to the Secretary of State, and so we therefore intend to proceed with implementation. But without a Green Bill this session I regret that we cannot take forward the proposal immediately. We do however remain firmly committed to it, as I hope what I will say later about central guidance machinery will demonstrate. I would also like to make it clear that we do not see the failure to gain Parliamentary time this session as in practice delaying the time when local authorities will have these powers over the full range of processes. The intention had been to establish an enabling power to allow local authorities to take control over part B processes incrementally. Under regulations they would be given responsibility for each process when the guidance for it has been agreed nationally after full consultation between the pollution control authorities (ie the Inspectorates and local authorities) and industry groups. As I hope to set out in a moment, we are now working up proposals for setting up the co-ordination machinery to produce this guidance. By the time the guidance is agreed, we should have the powers to allow local authorities to assume control responsibility.

SCHEDULED PROCESSES

The consultation paper also made proposals for a significant increase in the range of processes to be scheduled for prior control and for some processes now controlled by the

Inspectorates to be passed to the local authorities. The broad allocation was again very well received - 47 for, 3 against. We intend very shortly to issue for consultation a detailed draft of the new schedule of works. It will be in a different format from the 1983 schedule as it will set out the processes by 6 major categories following more closely the order in the Framework Directive. It will therefore cover fuel and power industries; production and processing of metals; non-metallic mineral-based products; chemical manufacturing; waste disposal works; and others.

But this new schedule will not take effect until local authorities are given new prior control powers. As I said earlier, we therefore intend at this stage, and only as an interim measure, to extend the 1983 schedule to include the new processes, eg municipal waste incineration, that are to come under the Inspectorates' control.

OFFENSIVE TRADES

In relation to the schedule, I should like to refer specifically to one process - offensive trades. Again, our proposal to include these under a new system of local authority prior control was generally welcomed, by 71 to 4. But there was substantial opposition (40 replies) to the proposal to exclude on-farm activities and 15 respondents objected to the proposal to exclude food manufacture. We are therefore looking at this question again very carefully.

SPECIAL INDUSTRIAL USE CLASSES

There was also opposition (60 against, only 6 in favour) to the suggestion that the special industrial use classes might be considered an unnecessary duplication of control once the new air pollution control system was introduced. Although many respondents favoured some simplification, there was evidence of a continuing need for the control system. The Department will shortly be letting a research contract to gather more information before an informed decision is taken.

AUTHORISATIONS

As for the proposed new system of consents - which we now intend to call authorisations - those commenting on it warmly welcomed it, by 49 to 2. But in response to comments made by many of those supporting the proposal in principle, we are reconsidering making failure to comply with the details of an authorisation an offence. This has been the line taken by the Royal Commission on Environmental Pollution in its Fifth Report. Certainly it will make the BPM duty as set out in an authorisation more comprehensible to the public.

CHARGES

The consultation paper also indicated that we would be considering further whether to charge for authorisations for local authority and Inspectorate controls. We plan to issue a further consultation paper on this, taking into account the 3 to 1 majority in favour of charging and the strength of feeling against imposing an additional burden on business. Clearly, too, any charging regime would have implications both for local authorities and for the Inspectorates' enforcement activities across other media. But charges could help to off-set some of the costs that the new system will impose, particularly on local authorities. We also recognise of course the need to minimise the potential burden on business. Local authorities - and others - generally queried the validity of our estimate that the new system would cost an additional half a million pounds a year, considering it to be a significant underestimate. I believe that many of these fears were unfounded. But we will be looking at these questions and, for example, the need for monitoring and training, as part of the co-ordination machinery we are planning to set up - which I would like to discuss in more detail in a moment.

APPEALS

Appeals to the Secretary of State against details of an authorisation, or delay in its delivery, were warmly supported. And most of those commenting thought that decisions on a authorisation should be made within 2 or 3

months - with the time running from the date that all required information was received. We are drawing up proposals in line with this to be discussed at the meetings I mentioned earlier.

CO-ORDINATION MACHINERY

At these meetings we will also be discussing the co-ordination machinery for the production of central guidance and the provision of assistance to local authorities in implementing the new regime in relation to a particular works. We are looking at something along the lines of the HELA model for local authority liaison with the Health and Safety Commission on working protection. As I indicated before, there was widespread agreement that this would be essential to the success of the new system and public and industrial confidence in it. I think that this point is well taken by local authorities generally.

There was general support (67 to 7) for the proposal to make more information about air pollution control available to the public. This is something we plan to discuss further with relevant groups and it will form part of the trials of authorisations that the Inspectorates are setting up that referred to at the outset of my paper. We will need to look particularly carefully at what information is available about each works' performance against the authorisation and the need to protect information which is commercially sensitive. We shall of course also continue to make considerable use of the Inspectorate's national and local reports.

A number of other issues were raised in the consultation paper, particularly in Annex D, which will be for future legislation when Parliamentary time is available.

CONCLUSION

I am grateful to the Society for inviting me to come today to set out what responses we had to our consultation paper and to tell you what our plans are for future implementation. It is disappointing that we cannot fully implement them now. But rather than delay all changes we believe it right to proceed as far as we can down the road

of Inspectorate implementation without jeopardising future local authority control. I hope that the meetings we are proposing with this Society and others will help to reach a continuing consensus on the details of implementation. It is gratifying that we received such general support for our proposals. We hope too that we can expect a similar response to the future consultation papers we will be putting out soon on the detailed schedule for parts A and B control, and I look forward to an interesting debate on the issue of the merits of introducing charging for authorisations.

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NATIONAL AIR POLLUTION MONITORING PROGRAMMES

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1. INTRODUCTION

The monitoring by the Department of the Environment of air quality on a national scale in the UK has undergone some major changes in the past 5 years or so. It is the intention of this paper to describe briefly these changes and to report on the current status of national air quality monitoring in the UK. The changes have involved an increased level of monitoring by the Department of the Environment. An increasing emphasis has been given to air quality in rural and remote areas with significant increases in monitoring of ozone and NO_x in rural areas, together with the establishment of nationwide acid deposition networks. There has also been a change in emphasis in urban air quality monitoring for, while smoke and SO_2 measurement sites have decreased, a new urban network to assess compliance with the EEC nitrogen dioxide (NO_2) Directive has been established.

This paper will deal with the monitoring of smoke and sulphur dioxide (SO_2), lead and nitrogen dioxide, the airborne pollutants for which EEC Directives on ambient air quality exist. Following this, a discussion will be given of the current position of the national ozone/NO_x and the acid deposition networks. The paper will summarise the present status of national air quality monitoring in the UK, giving an update on the measurement networks, and will highlight some of the more important recent results obtained.

2. SMOKE AND SULPHUR DIOXIDE (SO_2)

Monitoring of smoke and SO_2 was established on a country wide basis in 1961 by WSL, who have co-ordinated the so-called National Survey of Smoke and SO_2, including processing, publication and interpretation of the results on behalf of successive Government Departments, currently the Department of the Environment. Initially there were some

500 sites and the number increased steadily to about 1200 by 1966. Thereafter the number remained relatively stable demonstrating a high degree of commitment and effort by local authorities and other co-operating bodies carrying out the monitoring at their own expense.

However, during the lifetime of the National Survey, urban concentrations of smoke and SO_2 decreased significantly for a number of reasons. Smoke concentrations decreased because of the declining use of coal following the 1956 Clean Air Act and the move towards cleaner fuels such as smokeless fuels, gas and oil. The decrease in urban SO_2 concentrations has also been marked although not as large overall as that observed for smoke. As a result, the overall number of sites was reduced and the monitoring was reorganised in 1982 to form the three urban UK Smoke and SO_2 Monitoring Networks and a rural network. A preliminary discussion paper on this topic was presented to an earlier NSCA Workshop (ref. 1). The new networks are:

(i) The Basic Urban Network comprising 175 sites in urban areas. The network will be operated over a long period in order to assess urban exposure and to evaluate trends.

(ii) The EC Directive network, comprising 371 sites in April 1987, where measurements are made to assess compliance with the EC Directive on smoke and SO_2.

(iii) A network of 22 sites in support of an epidemiological study being carried out by St Thomas' Hospital. This network is likely to be of limited duration.

(iv) A reorganised and improved rural network, incorporating improved SO_2 measurement methods.

Originally the major emphasis of urban measurements of smoke and SO_2 was in the assessment of concentrations in relation to health effects and health-related standards and guidelines. While this is still an important reason for monitoring, interest has recently turned to the effects, particularly of SO_2, on damage to buildings and materials, and in 1985 DOE set up the Building Effects Review Group

(BERG) to assess the problem. Data from the UK Smoke and SO_2 Networks have proven very useful in this assessment and the Group's first report is due to be published in autumn 1987. Of particular importance to an assessment of the current position regarding possible material damage and the efficacy of possible control measures is the conclusion, drawn from an assessment of the measured data and from dispersion modelling studies, that in a large number of towns in the UK the current contribution to annual average SO_2 concentrations from sources outside the towns in question can reach 40-50%. The exceptions are those relatively large towns with a population of several hundred thousand which lie outside the higher SO_2 regions of the UK, but even in these cases the external contribution is generally of the order of 30-35%. The reasons for this proportional shift in source contributions arise from the changing patterns of fuel use in the UK. At the present time, 70% of UK SO_2 emissions arise from power stations and a large proportion of the external contribution to urban SO_2 concentrations arises from these sources. Future trends in SO_2 concentrations will be followed by the Basic Urban Network.

The EC Directive Network includes some sites of the Basic Urban Network and was first designated in 1982. The intention is that as smoke and SO_2 concentrations decrease in particular locations and WSL/DOE are satisfied that the EC Limit Values are unlikely to be breached, sites would be removed from the network.

There are areas in the UK where the EC Directive limit values are currently exceeded, and Figure 1 updates a previous summary given to an NSCA Conference (ref. 2) of the number of sites in the UK where this occurs. There has been a major improvement as a result of the increasing areas under smoke control since the early 1960s, and the sites which still exceed the limit values generally do so because of elevated smoke concentrations arising from coal combustion, primarily in domestic use.

The original National Survey included some 150 sites in rural communities and country areas. With the increased interest in the transport of SO_2 and other pollutants outside the urban areas, WSL began to consider a revision of the earlier

rural monitoring network. This was given added impetus by the Tenth Report of the Royal Commission on Environmental Pollution which recommended that further consideration be given to the size of the baseline rural network for smoke and SO_2 and that WSL should also continue to improve methodology for the measurement of SO_2 in rural areas.

Accordingly, in liaison with the DOE and the Review Group on Acid Rain, WSL has proposed the revised rural smoke and SO_2 network shown in Figure 2. Some of the sites in the network will be sites in the primary acid deposition and NO_x/O_3 networks, others will be sites currently operated as part of the existing network. Furthermore the methods of measurement used will be specific for SO_2, in that at most sites the British Standard smoke and peroxide bubbler apparatus will be used, with the alkali titration replaced by analysis by ion chromatography for sulphate; at the sites shared with the NO_x/O_3 network pulsed UV fluorescence continuous methods will be used.

The new network will therefore give a more structured approach to rural smoke and SO_2 monitoring than has been available in the past and will, for the first time, provide up-to-date specific measurements of rural SO_2 concentrations on a national scale. These data will enable assessments of SO_2 exposure in rural areas to be made on a national basis and will also be extremely valuable in the validation of numerical models of SO_2 transport on a national and international scale. An example of the results from such a model (ref. 3) is given in Figure 3 which shows a calculated non-urban SO_2 distribution over the UK and a comparison of the model calculations and observed values at WSL's rural measurement sites.

In contrast to urban SO_2 concentrations, which have decreased by roughly a factor of five over the past twenty years, rural concentrations have decreased by a much smaller amount. This is because concentrations in areas remote from sources are, to a good approximation, proportional to the total emissions, rather than to a combination of emission and a source height term which influences near field concentrations. The shift from low and medium height SO_2 emissions to high level sources has decreased urban

concentrations quite markedly but concentrations in remote areas have followed total emissions. This is shown in Figure 4 where sites in rural areas have been classified into two sets, one incorporating sites within 10 km of an urban area and the other at distances greater than 10 km from urban areas. It is clear from this plot that SO_2 concentrations at the "near-field" sites have decreased much more than those in more remote areas.

LEAD

WSL is carrying out measurements of airborne lead on behalf of DOE in two projects. The first is to assess the trends in airborne lead concentrations as the lead content of petrol in the UK reduces from values of 0.55 g l^{-1} in the early 1970s to an average value of 0.38 g l^{-1} in 1985 and subsequently to a maximum permitted content of 0.15 g l^{-1} as of 1 January 1986. The resulting changes in airborne lead concentrations are shown in Figure 5 where the decrease in airborne lead concentrations in 1986 following the decrease in lead in petrol is shown very clearly. Lead measurements are being made at eight locations as part of the Lead in Petrol Survey as well as at four Multi-Element Survey sites, where other trace elements are also monitored for long-term trends. The second project concerns the assessment of concentrations in relation to the EC Directive on airborne lead (limit value 2 ug m^{-3} annual average). With the reduction in the lead content of petrol, traffic sources have decreased in importance vis-a-vis the Directive and measurements are primarily concerned with industrial sources of airborne lead.

NITROGEN DIOXIDE EC DIRECTIVE NETWORK

Following the publication of the EC Directive on ambient NO_2 concentrations in March 1985, WSL has established sites to measure NO_2 concentrations, for the Department of the Environment. The sites will be used to assess the individual risk of exposure in excess of the limit value which is 200 ug m^{-3} (100 ppb) as a 98th percentile of hourly values over a calendar year. There are initially six sites covering urban areas likely to be most heavily influenced by NO_x emissions from traffic sources and industrial areas where stationary

sources may be important. In order to assess the relative NO_2 concentrations in a large number of urban locations in the rest of the UK, WSL in conjunction with AERE, Harwell and with the assistance of many local authorities, has carried out a survey using NO_2 diffusion tubes - a very cheap, robust and reliable method for measuring ambient concentrations. The survey ran from July to December 1986, and covered some 433 sites mostly in urban areas. The EC Directive also requires Member States to make measurements in zones where fixed sources make a significant contribution and several sites in the UK are under active investigation. The location of monitoring sites in urban and industrial areas has been determined from the outcome of preliminary investigations using the WSL mobile laboratory and the results of numerical dispersion modelling techniques, in conjunction with the National Physical Laboratory and AERE Harwell.

The network of sites which commenced operation in January 1987 is shown in Figure 5. All sites are linked by telemetry to the WSL master station and provide data, in terms of hourly averages, to WSL on a daily basis. The first reporting year is 1987 (calendar year) so that no data are available at the present time.

RURAL OZONE/NO_x NETWORK

Since the early 1970s ozone, and to a lesser extent NO_x, measurements have been undertaken at only a few rural and urban sites in the UK, mainly in the South East. The increasing interest in the concentration levels and distribution of these pollutants and in particular the significance of ozone in relation to crop and forest damage was recognised by the RCEP and the House of Commons Select Committee on the Environment. Following the reports of these bodies, DOE asked WSL to make proposals for an enlarged network of stations to monitor NO_x and ozone in a systematic way throughout the UK. Following discussions with interested organisations including the Institute for Terrestrial Ecology (ITE), University of Manchester Institute of Science and Technology (UMIST), Harwell, Forestry Commission, Meteorological Office, Imperial College and the Central Electricity Board (CEGB), the final network of some 17

stations was agreed; some of these organisations are establishing and running sites on an interim basis before handing over to WSL. The intention is that this network (Figure 6) will ultimately be co-ordinated by WSL.

This network is essentially the primary network operating to a set of protocols developed by WSL. Data from other organisations with sites operating at a secondary level will be accepted and used to supplement the network where appropriate.

The objectives of the network are:

- to provide a general picture of the spatial distributions of NO_x/O_3 over the UK;

- to assist assessment of the impact of NO_x/O_3 on sensitive areas;

- to permit trend analysis as the data accumulate;

To fulfil these objectives, sites have been chosen to cover as wide a range of land use types, geographical locations and altitudes as is practicable. Some sites are more specifically related to one objective whereas others fulfil several objectives. The monitoring stations will operate with the most sophisticated available monitoring equipment to give continuous data on NO, NO_2 and O_3, with SO_2 being measured at some locations. WSL has designed the stations to be fully automatic. An intelligent data logger and site controller at each station record and average pollutant concentrations, monitor instrument diagnostic alarms and control a daily calibration sequence for all air quality monitors. The sites operated by WSL transmit data by telemetry to the WSL master station.

It is anticipated that the network will be complete by 1988 and the data from the network sites will provide the UK input to the OECD NO_x/O_3 data exchange.

In parallel with this network, the Department of the Environment has also set up the Photochemical Oxidants Review Group which is charged with assessing photochemical

oxidants in the UK. The first (interim) report of the Group was published in February 1987.

Currently 16 sites are operating with ozone instruments, of which 8 are providing data by telemetry to WSL. The installation of NO_x monitoring has been delayed due to instrumental difficulties, but NO_2 diffusion tubes have been installed at the primary acid deposition sites providing fortnightly concentrations of NO_2 in these rural areas.

Nonetheless, the network now provides for the first time in the UK a comprehensive coverage of the country in terms of ozone measurements. A good example of the information which is now becoming available for the first time is afforded by the results obtained during a period of photochemical ozone production which occurred in the latter half of April 1987. The period was notable, not so much for the magnitude of the ozone concentrations measured (which were at maximum 90–107 ppb hourly averages) but that it occurred relatively early in the year. (In fact only at the CEGB site at Bottesford had higher hourly ozone concentrations been observed in any previous April in the UK, in 1979 and 1980).

Time series of hourly ozone concentrations at the WSL sites are shown in Figure 6 from which it can be seen that elevated ozone concentrations were observed in two periods, (i) 16–18 April and (ii) 23–30 April. During both periods hourly average concentrations of ozone greater than 60 ppb were observed, indicative of photochemical production in the polluted boundary layer. Furthermore, in both periods elevated concentrations were observed over a large area, from southern England (at the Lullington Heath, Sussex and Stevenage sites see Figure 8) to the west coast of Ireland (Mace Head and Lough Navar) and in the second period, the north of Scotland (Strath Vaich). The synoptic meteorology of both periods was characterised by anticyclones centred over Central Europe with relatively high temperatures and broadly south-easterly air flows. Both periods thus experienced dry, warm continental air, clear skies and high temperatures (maxima in the UK on 17 April reached 21 ^{o}C and on 27 April maxima reached almost 24 ^{o}C. It is intended that a more detailed analysis of this episode is to

be published at a later date.

6. ACID DEPOSITION

In their 1983 report 'Acid Deposition in the United Kingdom' (ref. 4), the members of the United Kingdom Review Group examined the distribution of acidity, and other ions relevant to acidity, throughout the country and found that sufficient data were available for the period 1978-1980 to allow maps of rainfall acidity and other constituents to be drawn for $\sim$60% of the land surface of the United Kingdom. Moreover, the Review Group also found that while past data on rainfall composition were available from as long ago as 1861, the quality of these data and their lack of continuity precluded the reliable quantitative estimation of trends.

The Group made a number of recommendations concerning the further investigation of acid deposition over the UK, and following discussions among interested parties, co-ordinated by the DOE, four main objectives were identified for future rainfall composition monitoring in the United Kingdom.

- To determine spatial distributions of acidity and other relevant ions over the UK.

- To assist assessment of the impact of acid deposition on sensitive areas.

- To permit trend analysis as the data accumulate.

- To attribute sources and to assist the understanding of the processes leading to acid deposition.

It was recognised that these objectives could not be met by a single monitoring network and it was agreed that three levels of monitoring were required:

(1) A small primary network providing high quality measurements of precipitation composition and related species to allow attribution to sources, determination of trends with time and validation of a much larger secondary network.

(2) A secondary network which would delineate the regional patterns of concentration and deposition of acidity and other major ions in precipitation. Several organisations would contribute to this network and, hence, central co-ordination and quality assurance would be essential. This network would also assist validation of other measurements eg "tertiary networks".

(3) Tertiary networks consisting, in effect, of additional ad hoc measurements carried out for special or local purposes; for example, monitoring in support of effects studies in sensitive areas not already covered by the primary and secondary networks.

Moreover, to ensure a reliable database, the Review Group recommended that sound operating protocols and quality assurance methodologies be developed. The group drew up general operating protocols which WSL has developed and implemented.

The Primary Network (see Figure 9) consists of nine sites providing high quality data on a daily basis using wet-only collectors. Analysis of the rainwater samples is carried out for conductivity, pH/H^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+} and for the anions NO_3^-, Cl^-, SO_4^{2-} and, where pH $\sim$5.6, HCO_3^-. At all primary network sites gaseous NO_2 concentrations are measured on a 2-weekly or monthly basis using diffusion tubes; SO_2 is measured on a daily basis using H_2O_2 bubblers with analysis by ion chromatography for sulphate ions.

Daily measurements of airborne particulate sulphate are made at all sites and in the future some sites will be used for shorter term measurements of HNO_3 and particulate nitrate. The infrastructure of the sites is such that other measurements of other pollutants can be added as necessary and a number of the sites are being used to expose stone and metal samples as part of a National Materials Exposure Programme co-ordinated by the Building Research Establishment. In addition, some primary network sites are co-located with new NO_x/ozone network sites. Moreover, the primary network forms the basis of the UK input to the United Nations EMEP (European Monitoring and Evaluation Programme) study.

The Secondary Network of acid deposition sites makes less detailed measurements than the Primary Network, using a standard WSL design of bulk collector, operating on a weekly or fortnightly basis. However, the spatial coverage is more detailed, providing for the first time a comprehensive coverage of the UK. In achieving this, the valuable co-operation of some 29 organisations has been forthcoming. The network which currently comprises 60 sites was begun in January 1986. Analyses are carried out for pH/H^+, NH_4^+, Cl^-, NO_3^- and SO_4^{2-} at all sites with Na^+, K^+, Mg^{2+}, Ca^{2+} and conductivity being measured at all but four sites.

Each primary network site will also have a secondary network collector to ensure that the results of the two networks are fully consistent and comparable.

Reports giving further details of the networks, operating protocols and siting criteria are available from WSL (refs 5 and 6).

With the establishment of these networks WSL is now in a position to provide, for the first time, a fully quality assured and controlled set of acid deposition data covering the whole of the UK. By paying close attention to the quality assurance and control aspects of the measurements and by ensuring a high degree of uniformity of operating protocols by means of central co-ordination, the quality of data now being produced for the UK ranks with the best in Europe and probably the world, both in terms of validity/confidence and spatial coverage. An example of the data produced for 1986, the first full year of operation, is given in Figure 10 which shows the precipitation weighted annual mean sulphate concentration over the UK. Space precludes a full discussion of the results but preliminary analyses have already been carried out (refs 7 and 8) and further publications will follow. The data for the species measured are already proving of great value in assisting and improving our understanding of the sources and sinks of particularly sulphur and nitrogen (both oxidized and reduced) in precipitation.

7. SUMMARY

This paper has described in outline terms the significant advances in air quality monitoring which the UK Department of the Environment has commissioned at WSL over the last three years. The national coverage has extended from the primary pollutants smoke and SO_2 to the secondary pollutants NO_2 and ozone and to the analysis of precipitation composition for species important in the acid deposition issue. The secondary pollutants NO_2 and ozone have been measured by WSL and others for many years but the new networks represent the first full coverage of the UK on a national basis. In accomplishing this, improved techniques are being used, particularly regarding the telemetric data handling in the ozone and NO_2 networks. Furthermore, all the data for all the species collected by WSL are being archived in a very flexible relational database with an associated software system which allows a wide range of analytical procedures to be carried out on the data.

As a result of this major expansion of effort there is therefore now in the UK for the first time a centrally co-ordinated integrated database on all the major air pollutants, at a level of quality, validity and spatial coverage which ranks with any other country in Europe and probably the world.

8. ACKNOWLEDGEMENT

The work described in this paper forms part of the Air Pollution Research programme of the Department of the Environment.

. REFERENCES

1. A W C Keddie, F P Williams and B D Gooriah, Future Measurements of Smoke and Sulphur Dioxide in Urban Areas of the UK, Paper to NSCA Workshop 'Monitoring - Where Next?' Newcastle, April 1981.

2. B D Gooriah and M L Williams, Progress in Meeting the EC Directive with Specific Reference to Smoke Control. Paper to 49th NSCA Annual Conference, Llandudno, October 1982.

3. D A Perrin, Modelling the Transport and Removal of Sulphur Dioxide Emissions in the UK, Warren Spring Laboratory Report LR 560 (AP), 1986.

4. Acid Deposition in the UK, First Report of the Review Group on Acid Rain, Warren Spring Laboratory, 1983.

5. Future Acid Deposition Monitoring in the UK, Review Group on Acid Rain, Warren Spring Laboratory, 1986.

6. M Devenish, The UK Precipitation Composition Monitoring Networks, Warren Spring Laboratory, Report LR 584 (AP), 1986.

7. D A Perrin, Sulphur Deposition in the UK - A Comparison of Model Results with Measurements for 1986, Paper to International Conference Acid Rain, Lisbon, Portugal, September 1987.

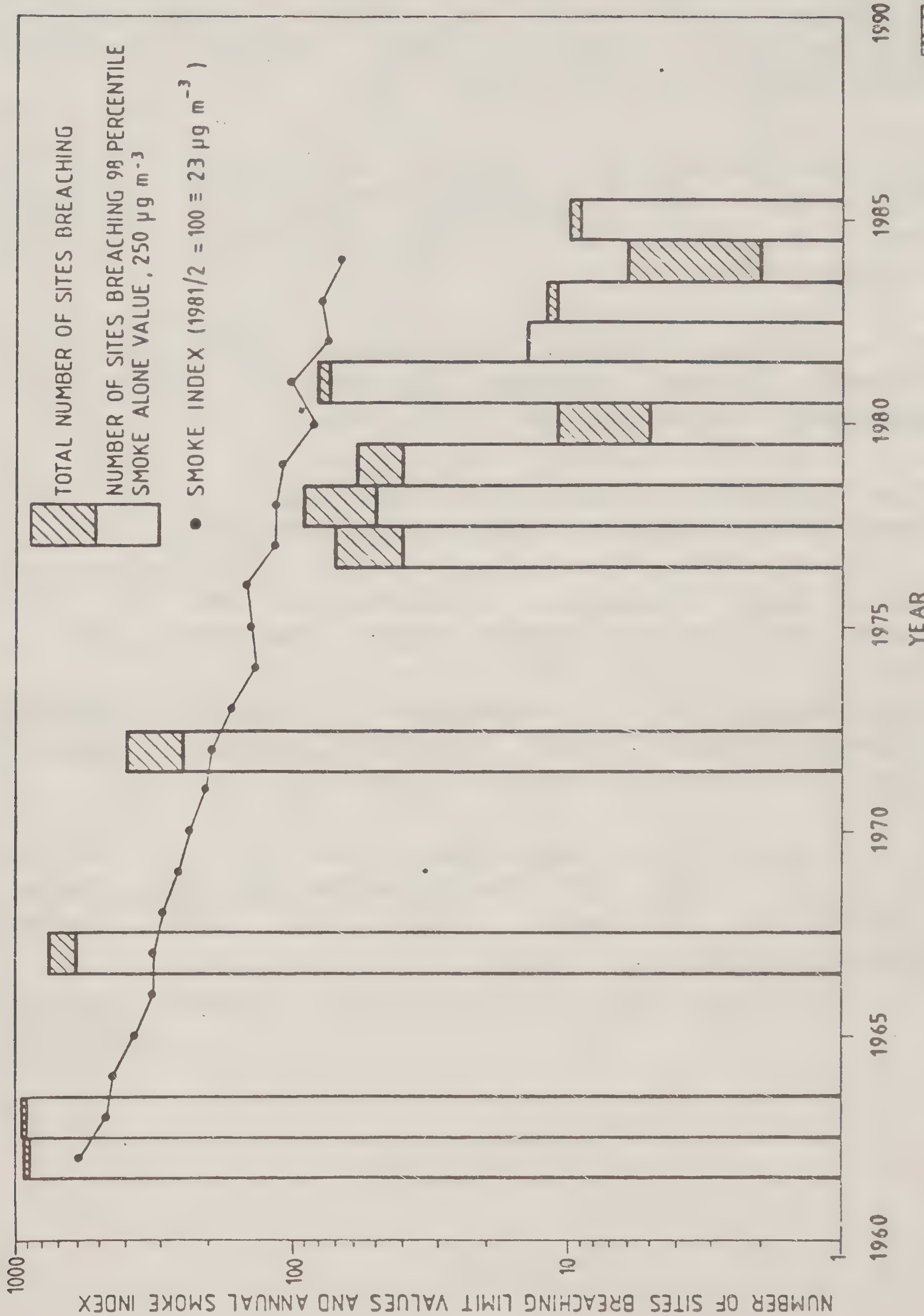


FIG.1 UNITED KINGDOM ANNUAL NETWORK INDICES FOR BLACK SMOKE

FIG. 2 BASIC RURAL SO_2 NETWORK

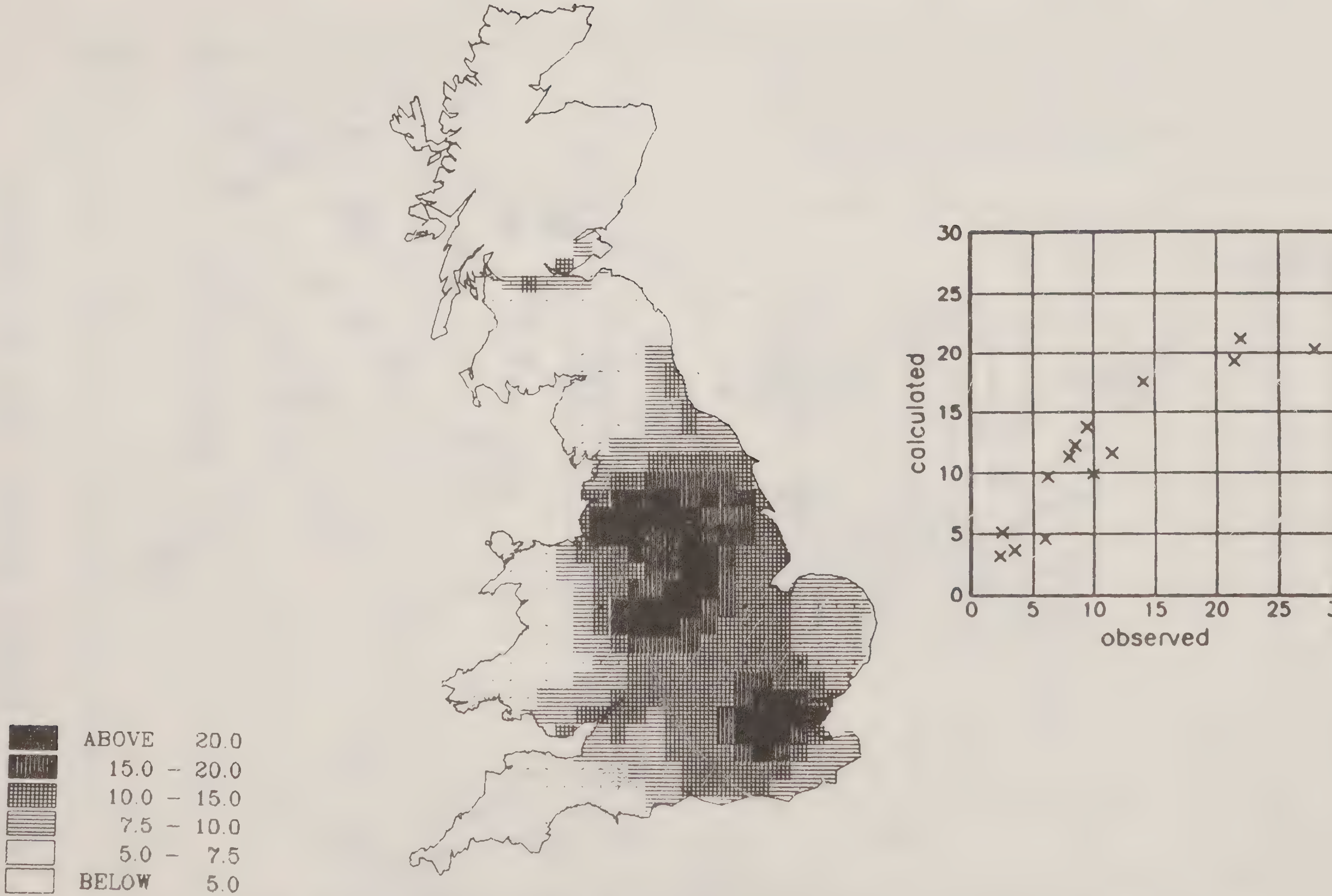


FIG.3 MODELLED SO_2 CONCENTRATIONS IN UK AND COMPARISON WITH OBSERVATIONS IN 1983

17566

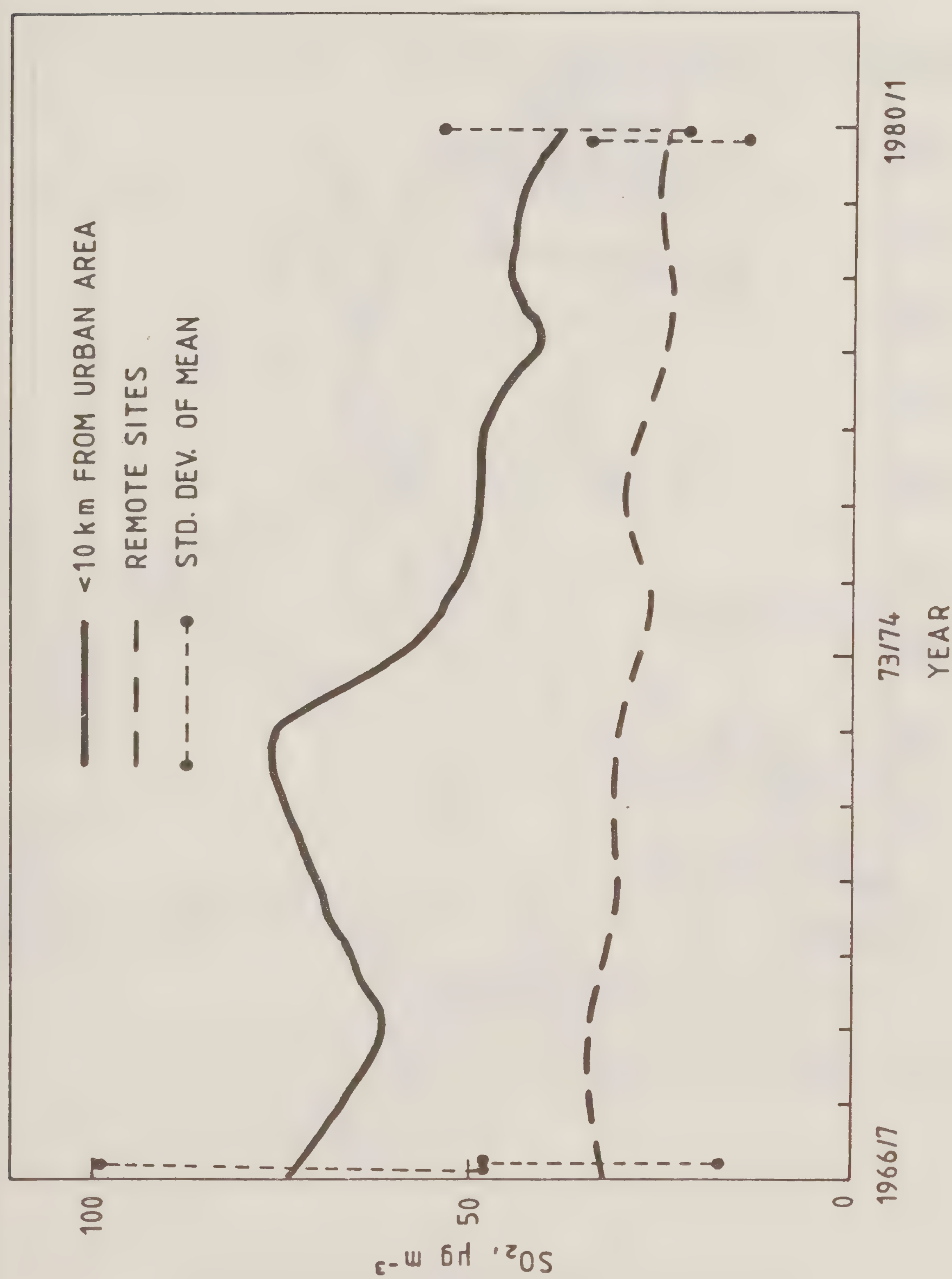


FIG. 4 ANNUAL AVERAGE SO_2, µg m^{-3}, AT RURAL NATIONAL SURVEY SITES

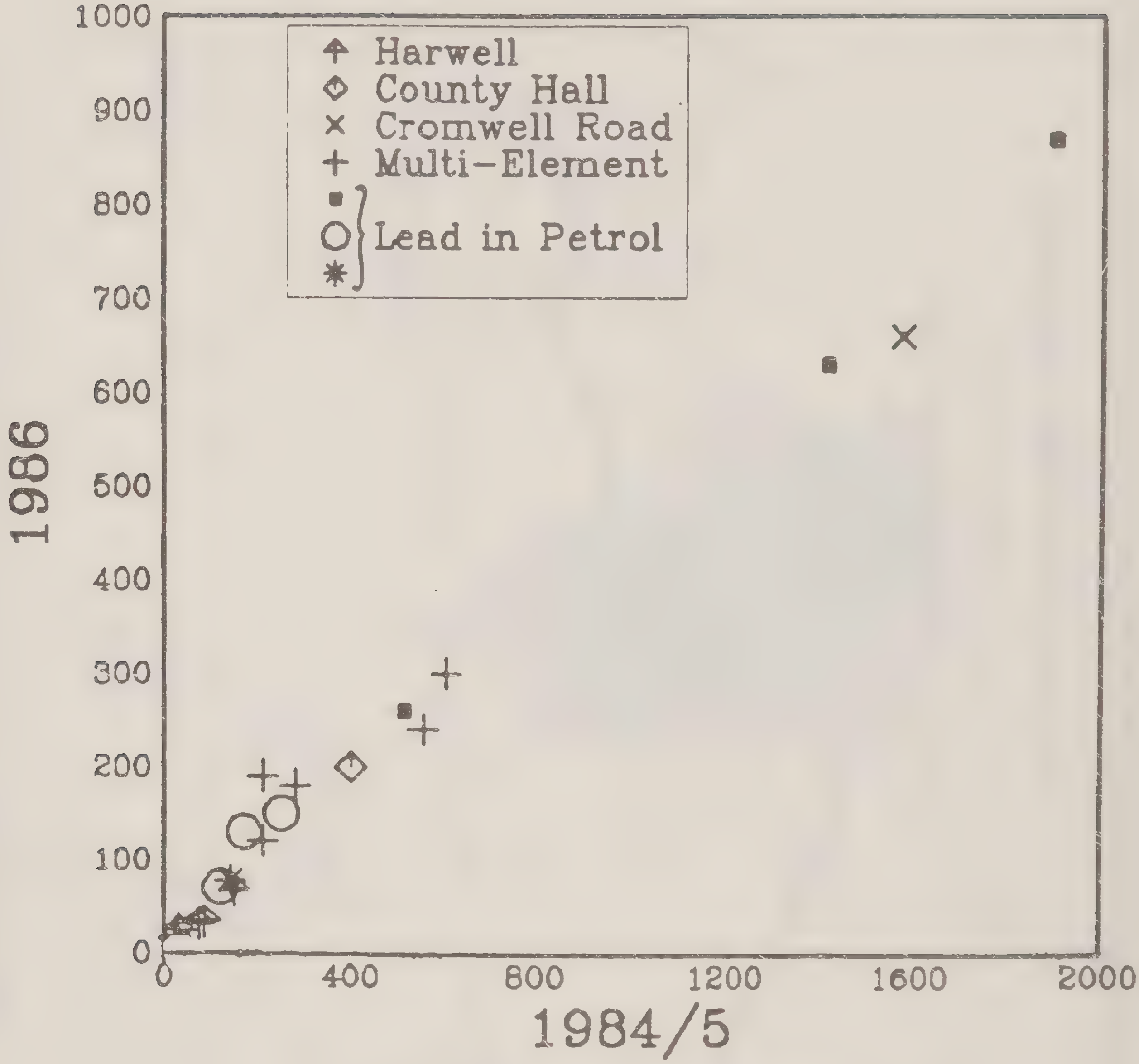


FIGURE 5. AVERAGE LEAD CONCENTRATION (ngm-3)
FOR 1986 vs 1984/5

FIG. 6 NO_2 DIRECTIVE NETWORK

FIG.7 OZONE / NO_x NETWORK

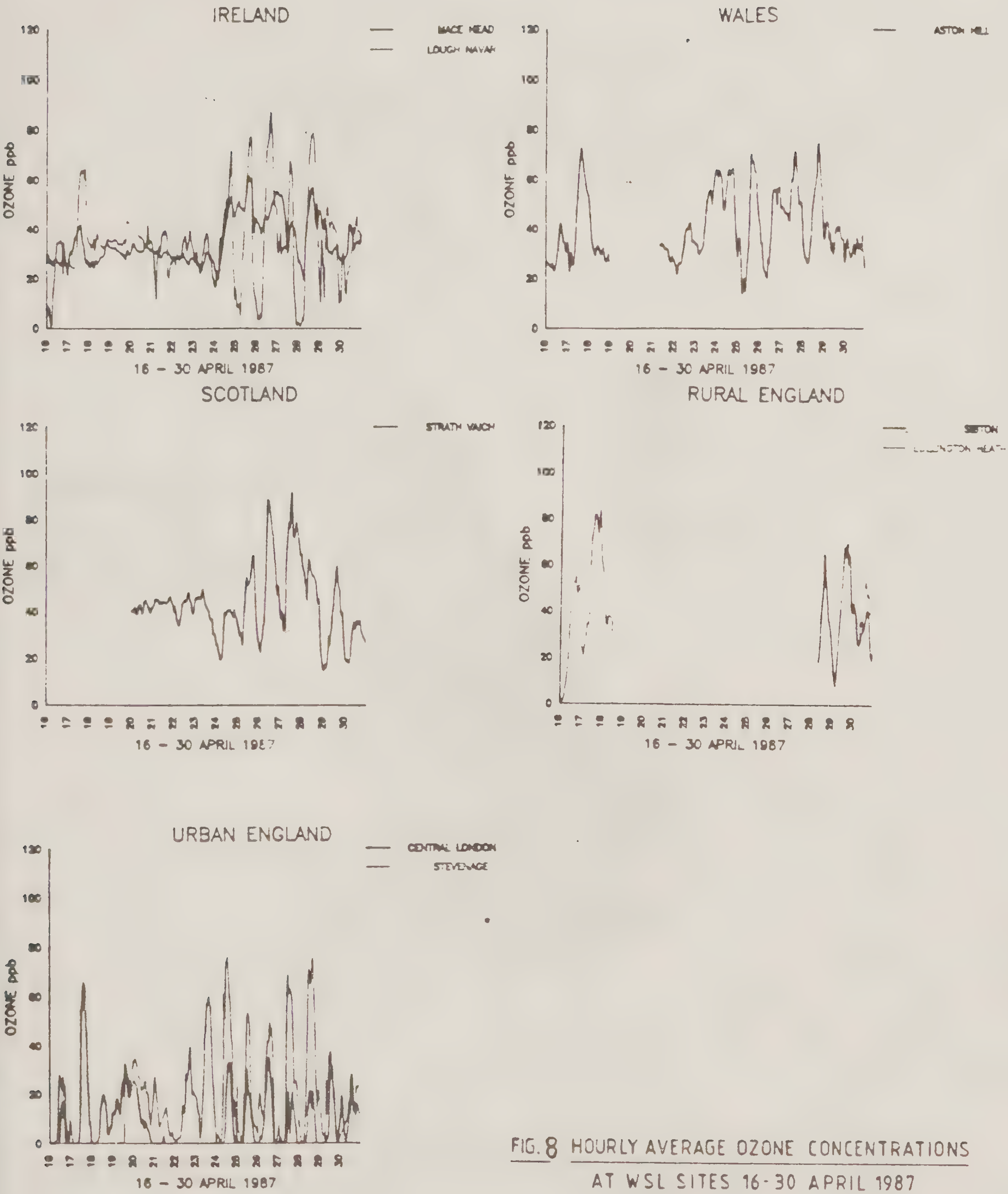
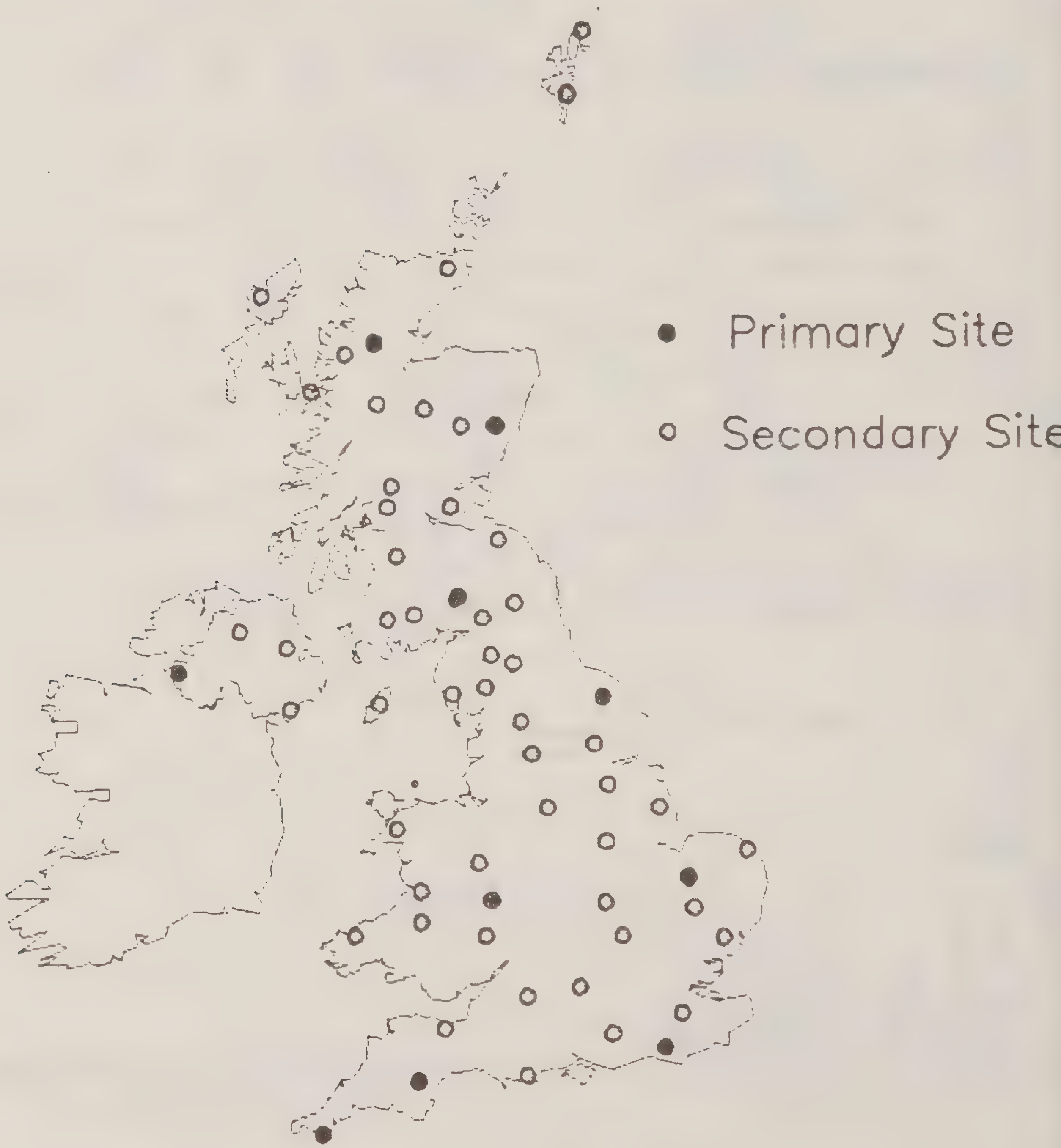


FIG. 8 HOURLY AVERAGE OZONE CONCENTRATIONS AT WSL SITES 16-30 APRIL 1987

Fig. 9

United Kingdom Precipitation Composition Monitoring Networks.



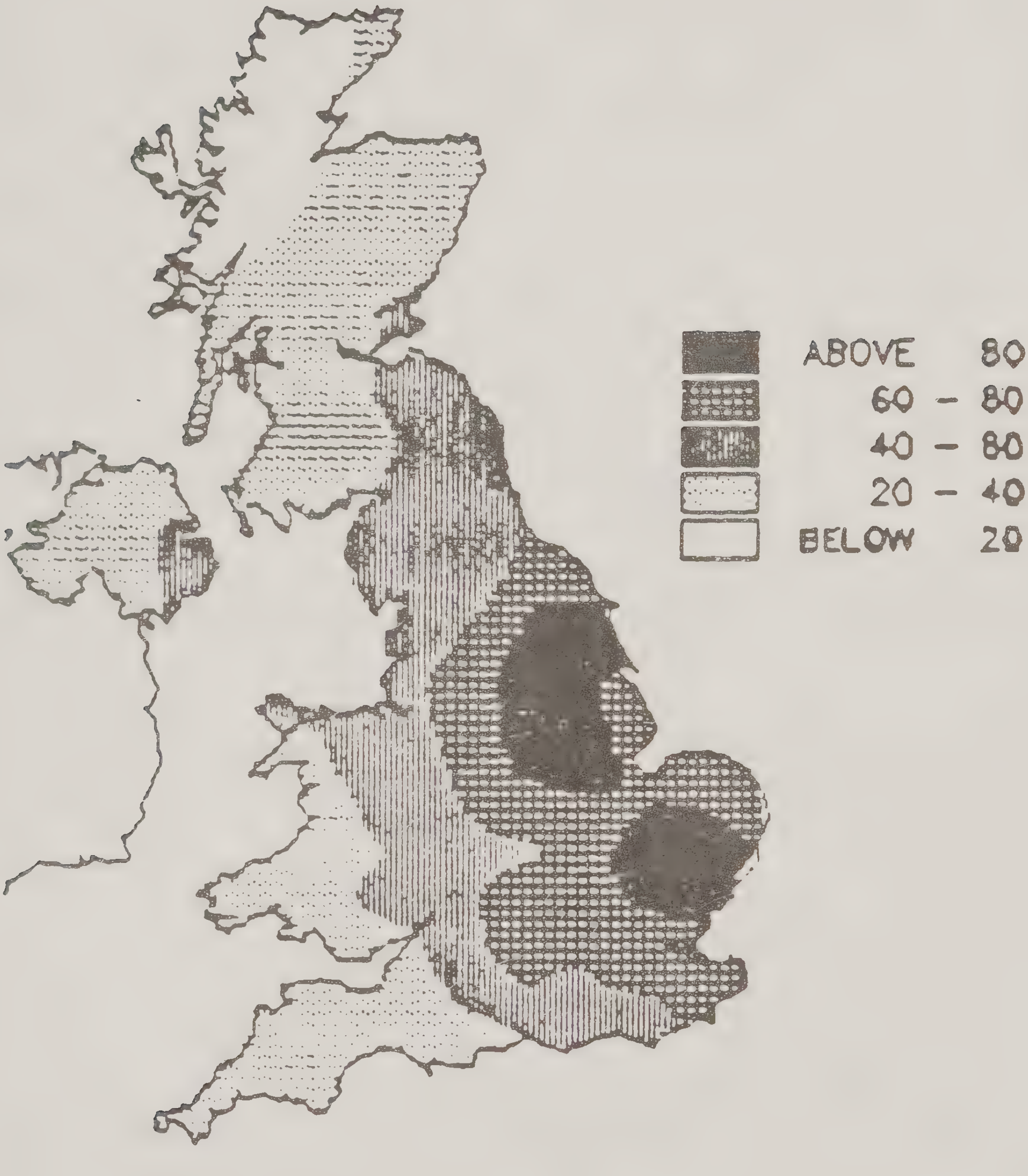


Figure 10. Precipitation Weighted Annual Mean Non-Marine Sulphate ($\mu eq\ l^{-1}$), 1986.

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DIOXINS
Sources, Combustion Theories and Effects

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INTRODUCTION

Polychlorinated dibenzo-p-dioxins (PCDDs) and the closely related polychlorinated dibenzofurans (PCDFs) constitute a group of chemicals that have been demonstrated to occur ubiquitously in the environment; they do not occur naturally and appear to have no commercial application.

The general public associates dioxins with the Seveso explosion in Italy in 1976, the herbicide spraying programme during the Vietnam War, and more recently with their presence in the emissions from waste burning incinerators. The media has generally concentrated on the more emotive aspects - for example, the deaths of farm animals and the potential threat to human health from cancer - but the toxicological information available to date is not easily interpreted and much more data is required before the environmental significance of these substances can be more clearly determined.

The whole dioxin story is extremely complex, with recognised experts in the field offering different theories covering the synthesis of dioxins, the significance of incineration as a major environmental source, and the long term effects of these substances on public health.

It is not intended that this paper should provide a comprehensive account of the dioxin issue but will simply concentrate on some of those aspects that have received relatively little attention in the media:

- What are the sources of dioxins and how are they formed?
- What health risks have been identified?
- How can their presence in the environment be controlled?

SOURCES

It is recognised that dioxins arise in the environment from three general sources:

- as trace contaminants in commercial products
- major accidents
- combustion sources

Trace Contaminants

Dioxins, particularly the most toxic 2,3,7,8 tetra chlorinated isomer (TCDD), were present in the herbicide mixture known as Agent Orange used during the Vietnam War in the late 1960s. Agent Orange consisted of a mixture of the 2,4D and 2,4,5T butyl esters of chlorphenoxy herbicides and 50,000 tonnes were sprayed as a defoliant. The presence of TCDD was unknown at the time but later analysis of unused drums showed the mixture to contain between 0.02-54ug/g TCDD. Since this time, the manufacture of 2,4,5T has been generally replaced by other herbicides, but where it is still produced, the TCDD concentration is strictly limited to less than 0.01ug/g.

Dioxins have been detected in some chlorophenols which have been used extensively since the 1930s as fungicides, mould inhibitors, antiseptics, disinfectants and insecticides. The most important use of the tri, tetra and penta chlorophenols is for wood preservation but they are also used for slime control, tanning leather, and in paints and glues.

Major Accidents

There have been a number of major accidents where dioxins played a part:

Seveso, Italy 1976

Binghamton State Office Fire, New York 1981

Love Canal, Niagara 1979

Missouri Horse Arenas, 1971

Times Beach, 1982

Yusho Disease, Japan 1968

Taiwan, 1979

Combustion

Emissions from incinerators, covering dust, smoke, toxic metals and acidic gases have long aroused concern but it is only during the last 10 years that the presence in these emissions of hazardous organic substances, including dioxins and furans, has been recognised.

It was in 1977 that Olie reported the occurrence of PCDD and PCDF in the fly ash from 3 municipal incinerators in the Netherlands, but at this time quantification was difficult because of the lack of synthetic standards. However, since then these findings have been confirmed and virtually all incinerators examined in Europe, USA, Canada and Asia have been found to emit dioxins and furans. For various reasons there is concern that at least some of the dioxins and furans are potentially a general health risk.

Although the amounts of PCDD and PCDF found varied by several orders of magnitude, some incinerator plants have been found to have emissions low enough to be acceptable on the basis of elaborate environmental impact studies. In general however, the concern about PCDD and PCDF emissions from combustion sources has caused some hesitation or delay in constructing more of these plants until it can be determined how emissions of these materials can be controlled to acceptable levels. Considerable research is at present underway, especially in Canada, USA and the Nordic countries where there is a particular desire to use combustion as a means of reducing the need for landfilling, while at the same time allowing useful energy to be recovered.

THEORIES OF DIOXIN FORMATION

While the origin of PCDD and PCDF from incineration processes has still not been clearly identified, they appear to arise, at least partially, as a result of complex thermal synthesis reactions during periods of poor combustion, and because of their high thermal stability can only be destroyed after adequate residence times at relatively high

temperatures.

Three theories have been proposed to account for the presence of PCDD and PCDF in the emissions from incinerators:

a) PCDD and PCDF occur as trace constituents in the waste itself, and a proportion simply survives the incineration process;

b) PCDD and PCDF are produced somewhere during the incineration process from precursors such as PCB, pentachlorophenols, chlorinated benzenes etc;

c) PCDD and PCDF are synthesised from materials not directly related to these compounds, eg petroleum products, chlorinated hydrocarbons, chlorides, plastics and other similar substances.

In the case of the first theory, some analysis of municipal waste has been undertaken to determine the presence and quantity in the waste of PCDD and PCDF. There is little reason to expect untreated refuse to be a significant source of these substances, and this is generally found to be the case. In fact, when the levels of PCDD and PCDF were measured in both the raw waste and in the emissions, there was found to be a considerable increase in the concentration of PCDD and PCDF passing through the incinerator, therefore supporting either or both of the other two theories.

In the second theory, precursors may be introduced into the incinerator as part of the waste and, when heated to temperatures below their destruction level, PCDD abd PCDF may be formed. Laboratory studies have shown this can happen.

Similarly, in the third theory, unrelated chemical substances present in the waste, eg plastics, chlorides from food waste and lignin materials, have also been shown to produce PCDD and PCDF under pyrolytic reaction conditions.

Results obtained from incinerators

Many municipal waste incinerators world-wide have been investigated, of varying ages and with waste inputs ranging from 10 to 2000 tonnes per day. The results obtained have indicated a wide range of PCDD and PCDF emissions spanning several orders of magnitude. High levels of emissions have been observed from several different types of incinerators, suggesting operational factors may have as much effect on emissions as does the design of the incinerator plant.

It is has not yet been generally possible to identify routes and operational conditions that clearly point to any specific route for the production of dioxins and furans, and the investigational work undertaken so far has shown that many factors may be involved.

Work in Germany on fly ash has indicated PCDD and PCDF are formed preferentially at 300 °C and their formation is favoured by low oxygen and high water vapour levels. The presence of unburnt carbon in the fly ash appeared to play some role as an adsorbent for precursor compounds, and copper also appeared to have a catalytic function.

Danish results showed high PCDD and PCDF levels were obtained with high carbon monoxide levels in the flue gases, during times of low furnace loading and with furnace and/or secondary temperatures less than 800 °C.

Detailed and substantial Swedish investigations have identified the chlorine concentrations of the waste, combustion efficiency and temperature of incineration to be important factors in the levels of PCDD and PCDF produced.

Work published earlier this year by Warren Spring found that, in a survey of several UK incinerators, the PCDD and PCDF content of grate residues, fly ash and stack gases varied widely from plant to plant, but were lowest from plants employing grates which agitated the feed. However, their results suggested that local operational practices and feed variability were also significant factors.

Although not specifically aimed at reducing dioxin and furan emissions, Italy has recently introduced legislation with the objective of improving combustion efficiency, requiring all waste incinerators to be equipped with a post combustion chamber which guarantees certain operative conditions including a minimum temperature of 950 ^{o}C for a minimum residence time of 2 seconds. The majority of existing facilities cannot comply with these requirements, and as a result, 50 of the country's 54 waste incinerators are threatened with closure.

HEALTH EFFECTS

A number of comprehensive reviews have been published dealing with the health effects of PCDD and PCDF, and several risk evaluations have been undertaken in various countries on the 2,3,7,8 isomer (TCDD), the dioxin of greatest known toxicological concern. However, isomers other than TCDD are considered to be of toxicological significance but work on these is very limited at present.

TCDD Equivalent

In order to take into account the toxic effects of many of the other isomers, the concept of TCDD Equivalent has been introduced whereby a cumulative assessment is made of the estimated toxicity rating of all the isomers relative to the most toxic isomer TCDD.

This concept involves the realisation that although TCDD has been established as the most toxic isomer, in some cases the low level of this isomer can be overshadowed by the presence of a larger quantity of a less toxic isomer. In order to assess the total contribution of all isomers of varying toxicity, several attempts have been made to allocate relative toxicity values to each isomer (and congener groupings), with the isomer having the 2,3,7,8 configuration being in each case assigned a higher value than the isomers in its group. An example proposed by Bellin and Barnes is shown below:

Dioxin isomer	TCDD Equivalent
2,3,7,8 TCDD	1.0
other TCDD	0.01
2,3,7,8 penta CDD	0.2
other penta CDD	0.002
2,3,7,8 hexa CDD	0.04
other hexa CDD	0.004
2,3,7,8 hepta CDD	0.001
other hepta CDD	0.00001

A similar approach is taken with the furans using a value of 0.1 as the relative toxicity value for 2,3,7,8 furan isomer. In this way, the total toxicological influence of the PCDD and PCDF can be considered in the presence of a variety of combinations of isomers and concentrations by the simple summation of all the values.

The application of TCDD equivalents clearly requires a detailed analysis of each component of the emissions under investigation and is very expensive to undertake. Nevertheless this is the approach being followed by most countries involved in dioxin monitoring work.

Toxicology

Available information on TCDD has shown this isomer to cause lethal effects in certain laboratory animals at lower levels than any other man-made chemical but both the lethal dose levels and toxicological effects vary considerably among different animal species. There is, however, considerably less information with respect to humans and most of the existing data have been derived from occupational exposure or industrial accident victims. In such cases the dose received by a given individual is virtually impossible to estimate, and the effects of similar exposures to other chemical species cannot be evaluated quantitatively in such cases.

However, there is general agreement that acute exposure to

dioxins can lead to chloracne, a persistent acne-like condition that can disfigure the victim although it does not appear to be life threatening. Acute exposure has also led to neurological complaints and liver dysfunction, but these problems are considered to be of a short term nature. Of greater concern is the possible linking of long term exposure of low enironmental levels of PCDD and PCDF to an increased incidence of cancer and the suppression of the immune system.

Based on animal experiments, using cancer, immunological or reproductive endpoint effects, and using a safety factor of 200-1000, a highest tolerable daily intake (TDI) for humans has been estimated to be 1-5pg/kg bodyweight of TCDD equivalent. The levels of TCDD equivalent found in human breast milk and certain fish do suggest that this TDI level may be exceeded in some countries.

Emission exposure can be direct through inhalation, ingestion and dermal absorption, or indirect through contributions to the environmental load and eventual exposure to man from food.

Inhalation

This is the most important route of direct exposure and dispersion models are generally used to estimate air concentrations to which people might be exposed.

From levels of PCDD and PCDF found in emissions from modern, properly operated incineration plant, a World Health Organisation working group recently calculated the worst case daily inhalation dose to be about 0.002pg TCDD equivalent/kg bodyweight, which is a very minor contribution to the TDI bodyburden of 1-5pg/kg.

For PCDD and PCDF levels from incinerators measured so far, having irregular operating conditions, high waste moisture content, low combustion or afterburner temperatures, and generally poor technology, the worst case daily inhalation dose was calculated to be around 0.3pg/kg, equivalent to between 6-30% of the TDI value.

This WHO report concluded that these doses were probably gross overestimates, and it was thought unlikely that the direct inhalation contribution of emissions from modern, well run municipal incinerators would make a significant contribution to the apparent background daily intake of PCDD and PCDF.

Indirect Exposure

Recent studies abroad have shown increasing levels of PCDD and PCDF in human breast milk but an assessment of the significance of these findings and possible correlation with incineration has not yet been undertaken. There is, as yet, no evidence for any contamination to drinking waters.

No estimate has been made at the present time of the indirect contribution of incineration to the background daily dose, but there may be certain population groups - those consuming milk produced solely in the immediate environment of an incinerator, and those consuming well above average meals containing certain fish - that may receive relatively higher exposure.

CONTROL OF PCDD AND PCDF IN THE ENVIRONMENT

If it is assumed that the presence of PCDD and PCDF as contaminants in certain chemicals has been reduced to acceptable levels, and that proper control of chemical processes will minimise accidents such as that at Seveso, then the remaining environmental source of dioxins and furans requiring control is that of emissions from combustion processes.

It is known that PCDD and PCDF are produced, albeit at extremely low concentrations, in certain motor vehicle exhausts, woodburning stoves, forest fires, stubble burning and certain industrial processes, but the major source is considered to be incinerators burning household, industrial and clinical waste. Even crematoria have been implicated.

The investigative work undertaken to date has shown the level of PCDD and PCDF emissions from incinerators to vary

widely and the factors causing these variations are not yet thoroughly understood. Nevertheless, there appears to be general agreement that conditions which improve (or optimise) combustion efficiency, including relatively high furnace temperatures, long residence times, together with high turbulence and excess oxygen levels, are likely to result in low PCDD and PCDF emissions.

In addition, it is also recognised that as well as modifications to design and combustion control facilities (some of which may be economically impractical or impossible in the case of some of the older incinerators), the installation of flue gas cleaning or abatement systems may also considerably reduce PCDD and PCDF emissions provided they operate effectively.

A large proportion of PCDD and PCDF produced during the incineration process is known to be associated with the fine particulate material, probably as a result of strong adsorption onto the surface of this dust shortly after formation. The incorporation of gas cleaning systems, eg settling chambers, cyclones, wet or dry scrubbers, electrostatic precipitators or fabric filters, will reduce the levels of dust and/or acidic gases released to the environment through the stack, thus also reducing the environmental burden of PCDD and PCDF. However, careful attention may then need to be directed towards the disposal of the collected residual material.

The installation of gas cleaning systems to new incinerators is virtually automatic nowadays, because of tighter environmental controls being applied to such plant. Following the recent lifting of its moratorium, Sweden has introduced strict new emission limits for all its waste-to-energy plants, including limiting dust emissions to no greater than 20mg/Nm^3. It is also one of the few countries to propose guideline PCDD and PCDF emission limits, calculated as TCDD equivalents, for both new and existing municipal waste incinerators, and intends to set definitive limits after a two year trial period. If such limits are established, they are likely to offer a technical challenge but also pose economic problems for those countries dependent on this form of waste disposal.

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PROTECTING THE COMMUNITY FROM TRANSPORTATION NOISE

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INTRODUCTION

Traffic, especially road traffic, is the most important source of noise, causing annoyance to a high percentage of people living in European countries.

The present situation is best demonstrated by a graph from a recent OECD report (1) shown in Fig. 1. About 30 to 50% of the population are exposed to equivalent sound levels exceeding 55 dB; 10 to 20% to equivalent sound levels exceeding 65 dB.

These sound levels have to be compared with the summarized results of research work as follows (1):

- below 55 dB in L_{eq} during the day (at housefront), damage caused by noise is very slight. Sound conditions enable the most noise-sensitive activities to be carried on normally;

- between 55 and 60 dB, noise impact remains limited, but some disturbance is probably occasioned to the more sensitive individuals, in particular older persons.

- between 60 and 65 dB, behaviour designed to reduce the annoyance is exhibited, although this is not too constraining. However, the effects on sleep and especially the level of annoyance increase very appreciably.

- above 65 dB, constrained behaviour patterns arise, symptomatic of serious damage caused by noise.

The results of the Austrian micro-census can be used to obtain details of annoyance caused by noise (Tables 1 and 2).

What could be done to reduce exposure to road traffic noise?

The origins of the high noise exposure are multiple and have to be seen with regard to

source - transmission - receiver.

The sources are again multiple, depending on
- vehicle-type and its noise emission
- road-type and noise created by road surface - tyre interaction
- the way a vehicle is driven

Noise transmission depends on the distance between source and receiver and intervening screens, ie on the sound path between source and receiver.

With regard to the receiver
- the position of houses
- the type of ground plan
- sound insulation of the buildings

influence individual noise exposure.

NOISE SOURCES

The work of working groups within international organizations like ECE (Economic Commission for Europe) or EEC (European Economic Community) has limited sound emission of vehicles by legal prescription in most countries.

It has, however, been shown in several reports that the present limits are higher than the state of the art would allow, applying to cars, as well as trucks and motorcycles. As an example a low-noise truck has been described and defined (2), (3) with the maximum sound-levels shown in Table 3.

Vehicles with additional noise relevant equipment such as pumps, stationary heating, air conditioning, refuse compacting drums, will only be classified as low-noise, where an additional examination will determine that these noise sources agree with the state of the art of noise control technology. This is held to be fulfilled, where the noise emitted by the additional units at their highest noise level is not louder than 65 dB at a distance of 7 m and does not contain tone components or impulse characteristics.

In Austria the legal limits for trucks are much higher; eg 86/87 dB (<150 kW) and 87/89 dB (>150 kW) (with or without 4-wheel drive) at present and 83/84 dB and 84/86 dB

respectively as from Oct. 1 1989.

As could be demonstrated, low-noise trucks will also be low-energy trucks and the additional expenses for the operation of low-noise trucks are only 0 to 2 % (4). It has been demonstrated in several reports that it is more effective to reduce vehicular noise emission than to construct road-side noise barriers (4), (5), (6). However noise emission limits are still high and noise barriers continue to be built. In Austria the following sums have been spent on noise control (construction of barriers, fitting of soundproof windows) along federal roads: 1985 - 391 mill. AS (Austrian schillings); 1986 - 466 mill. AS.

It is therefore proposed to introduce the definition of the low-noise truck in the relevant laws; the Federal Republic of Germany has defined the low-noise truck by law (3); in Austria the low-noise truck is so far described in the OAL guideline no. 29 and a law-bill is being drafted. Alternatively at least to do so by recommendations of national and international noise abatement societies to create incentives for the introduction of these vehicles, eg exceptional driving permits for residential areas, such as zones with driving bans during the night and the like. The city of Salzburg has, for instance, introduced a ban on night driving, the only exception being granted to low-noise trucks in accordance with the definitions in (2).

Apart from the noise due to vehicle construction, noise can also develop from vehicle handling. Differences in vehicular handling have been shown to be the cause of variations of up to 15 dB in sound level for cars, as well as for trucks (7). We may also state additionally: low-noise driving is equivalent to low-energy driving.

A greater effort should therefore be devoted to public education and advertising: people should be told that their low-noise driving contributes to noise control.

In the last 5 years a number of measurement studies have been undertaken with regard to low noise-emission road surfaces; in Austria and Germany these are designated "Flusterasphalt" (quiet black top) or better "draining asphalt".

The porous structure of the surface reduces the noise resulting from tyre-road contact, moreover the surface possesses a high sound absorption coefficient, reducing noise propagation and reflection. The latter effect is of special interest for urban roads. There is also no noise increase on wet roads. Table 4 shows an example of noise measurements on different road-surfacings.

Studies as to the role of speed-limits, especially for trucks, in the reduction of road noise, are at present being undertaken along the Inn Valley Expressway in the Tirol, the most frequented freight transit route through Austria. A night-time speed limit of 60 km/h for trucks has reduced the equivalent sound level for residential buildings at a distance of from 50 to 200 m by 1 to 3 dB. The reduction of the maximum sound level and the sound event level of the single passing trucks is shown in Table 4.

TOWN AND COUNTRY PLANNING

A great deal of noise annoyance is due to the fact that residential areas are close to through-roads carrying heavy traffic and main roads bisecting residential areas, as a result of town and country planning that did not include any noise abatement.

During the last decade in Austria and most European countries

- calculation methods to predict traffic noise (8)
- noise level limits for various zones

have been established, supplying planners with base data.

Now in Austria a new road may only be planned after an examination of its "environmental compatibility", which is based on calculations.

Noise maps and noise property registers have been established to

- avoid the construction of buildings in noisy areas, that will then have to be protected.
- avoid installations and buildings emitting noise in quiet

areas.

In the Austrian Regional Planning legislation various zones and installations, buildings, etc. have been classified with regard to noise emission and noise level limits (9). A short summary is found in Tables 5 and 6.

An international convention on such guidelines for noise level limits and noise emission would be very useful.

TRAFFIC PLANNING

Traffic planning can reduce noise levels under urban conditions. A situation with a few roads with high density traffic and residential roads for feeder traffic only will cope better with noise, than a traffic load split up among many roads.

For example, the opening of a new tangential highway in Vienna resulted in a noise level decrease for several through-roads passing through residential areas (10). Another series of measurements for the city of Graz demonstrated that the introduction of a one-way-road system within the city reduced traffic congestions and decreased air pollution considerably, but with more vehicles travelling at higher speed, noise levels increased (10).

Measurements for several cities demonstrated that a free flowing traffic system without interruption by traffic lights can reduce noise levels.

Reference should also be made to the attempt to shift private transport requirements to efficient public transport vehicles. Eg in Vienna the Vienna Underground and Rapid Transit network has been extended also for that reason.

NOISE CONTROL THROUGH ROADSIDE BARRIERS

Since

- legal limits for vehicular noise are still high
- and even the introduction of low limits will only reduce road noise levels gradually as new vehicles come onto

the roads and
- since reduced-noise road surfaces will take years to replace the present ones

the only immediately effective measures of noise control are barriers and earth mounds alongside roads. The last decade has seen the development of a large number of structures and products which - apart from being architecturally satisfying - assure sufficient sound insulation and high sound absorption.

Requirements for sound barriers have been established in Austria and Germany (11). A great many measurement studies on the acoustical quality have been executed on different structures and are now going to be published in a catalogue (12). This will include light-weight aluminium and steel-sheet structures, wooden barriers, concrete walls and many earth-filled concrete grid structures; these latter are often greened over.

It is interesting to note that formulas used to calculate the noise reduction achieved by a screen vary significantly from country to country (8). Here again an effort should be made to agree on the best formula internationally.

NOISE CONTROL AT THE RECEIVER

In the context of urban roads the most effective measure of noise control has been found to lie in the positioning of houses and their ground-plan. Sufficient protection is found with walled off gardens or courtyards and those facades facing away from the road. Houses within a closed development scheme have been found most advantageous, with living rooms and bedrooms along the "quiet" side.

In housing developments along urban roads with high traffic density only soundproof windows can give sufficient noise protection and in many Austrian cities such "Sound-protecting Window" schemes have been executed. Technical requirements have been laid down in (13). The state of the art permits the installation of windows with a high sound insulation, up to a weighted sound reduction $R_W > 50$ dB (equal to the usual exterior walls made of brick or concrete). The required rate of air-exchange has to be ensured by

technical means.

CONCLUSIONS

In summing-up it should be noted:

- road traffic is the most important noise source and annoys an important percentage of the public
- the state of the art of vehicular noise control is not yet used nor required by the legislation presently in force
- therefore there is an urgent need to define "low-noise vehicles" and to create several incentives to promote their use
- low noise driving also needs to be promoted
- more attention must be given to noise control in town and country planning; the data are available
- traffic noise planning can be used to control noise in urban areas
- an efficient public transport network can be used to reduce private transport and thereby to reduce noise
- noise barriers alongside roads and window sound-proofing have been highly developed and are widely used at present, although they are neither the best as to cost effectiveness nor the best with regard to quality of urban life.

REFERENCES

(1) Fighting Noise. Strengthening Noise Abatement Policies; OECD 1986

(2) OAL-Richtlinie Nr. 29 "Kriterien fur larmarme Lastkraftwagen und Omni-busse"; Wien 1987

(3) Anlage XXI zur Strassenverkehrs-Zulassungs-Ordnung in der BRD. Bundesgesetzblatt, Jahrgang 1984, Teil 1, Nr. 48, Seite 1396; Bonn, 24. November 1984

(4) A.v.Meier, P.H. de Vos: Noise reduction on road vehicles. Cost implications with emphasis on commercial vehicles. Report nr. GB-HR-25-02. Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer; den Haag, 1984

(5) G.Nielsen, S. Solberg: Costs and effects of traffic noise abatement measures. Basis for a national programme; Transportokonomisk institutt, Oslo 1985

(6) Kostnader ved stoydemping av kjoretoyer. Arbeidsdokument av 7.1.1985, Transportokonomisk institutt Norges Teknisk-Naturvitenskapelige Forskningsrad. Oslo

(7) G.D.Kemper: Noise emission from road vehicles and provisions for noise reduction. Proceedings Inter-Noise 85, Munchen

(8) J.Lang: Assessment of Noise Impact on the Urban Environment. A Study on Noise Prediction Models; World Health Organisation, Regional Office for Europe, Copenhagen 1986

(9) OAL-Richtlinie Nr. 21 (Blatt 5) "Schalltechnische Grundlagen fur ort-liche und uberortliche Raumplanung. Widmungskategorien"; Wien 1987

(10) J.Lang: Larmbekampfung durch Verkehrslenkung. AICB-KongreB Baden-Baden, Sept. 1978

(11) OAL-Richtlinie 23 "Massnahmen zum Schutz vor Strassenverkehrslarm - Planungsgrundlagen"; Mai 1983

(12) OAL-Richtlinie 23 (Blatt 2) "Massnahmen zum Schutz vor Strassenverkehrslarm - Larmschutzwande"

(13) OAL-Richtlinie 27 "Anforderungen an den Schallschutz von Fenstern bei der Vergabe von Forderungsmitteln": Mai 1983

Table 1
Noise Annoyance in Austrian Dwellings

Percentage of dwellings where residents are annoyed by noise

	1970	1973	1976	1979	1982	1985
total	50.1	49.1	53.7	42.1	42.4	38.8
slight annoyance	26.5	23.1	30.1	21.2	22.0	18.8
serious annoyance	14.2	15.7	15.4	13.2	12.8	12.5
very serious annoyance	9.4	10.3	8.2	7.7	7.6	7.5

Table 2

Percentage of dwellings where residents are seriously and very seriously annoyed by noise from various sources

	1970	1973	1976	1979	1982	1985
total	23.6	26.0	23.6	20.9	20.4	20.0
traffic noise	18.2	20.6	19.2	15.1	16.3	12.8
industrial noise	2.2	2.4	1.8	2.0	1.3	1.8
noise within the house	2.6	2.2	1.9	2.7	2.1	2.7
noise from other sources	0.61	0.70	0.76	1.0	0.7	2.7

Table 3

	A-weighted sound pressure level in dB with maximum power	
	< 150 kW	> 150 kW
driving noise	78	80
motor braking noise*	78	80
compressed air noise**	72	72
stationary vehicle noise**	78	80

* inasfar as relevant braking installations are built-in
** not present with electric drive

Table 4

Sound event level L_{AE} and maximum level $L_{A,max}$ of trucks on Autobahnen with different surfacings without and with speed limit 60 km/h

road surfacing	number of measurements	average speed (before and after introduction of speed limit)		maximum A-weighted sound-level (dB) not exceeded by			sound event level (dB) not exceeded by			
		$\bar{v}$	σ	10%	50%	95%	10%	50%	95%	average
concrete	108 86	75,7 62,2	8,8 6,7	83 81	86 83	89 87	86 84	88 86	90 89	89 87
asphalt	126 84	82,4 59,4	7,7 5,8	82 79	85 81	88 85	84 82	86 84	89 87	87 85
quiet asphalt	87 81	79,2 63,2	7,7 7,4	79 77	82 79	86 85	81 79	83 82	86 85	84 83

Table 5
Planning Values for Permissible Immissions (Immission Limit Values)
according to ÖNORM S 5021

Category[2)]	Area and locations	immission limit values in dB A-weighted, daytime: background level L_G	daytime: equivalent sound level L_{eq}	nighttime: background level L_G	nighttime: equivalent sound level L_{eq}
	A. BUILDING LAND[1)]				
1	quiet area, spa area, hospital	35	25	25	35
2	residential area in suburbia, weekend residential area, rural housing area, schools	40	50	30	50
3	urban residential area, area for buildings for agricultural and forestry enterprises with flats	45	55	35	45
4	city (offices, shops, commerce, administration without noise emission, flats) area for enterprises without noise emission	50	60	40	50
5	area for enterprises with little noise emission (distribution, services, administration)	55	65	45	55
	B. GRASS LANDS				
1	recreation area, spa area	35	45	35	45
2	parks, cemetries	40	50	--	--
3	games- and sport fields without noise emission, market gardens and allotments	45	55	45[3)]	55[3)]
4	games- and sport fields with slight noise emission	50	60	50[3)]	60[3)]
5	smaller games- and sports installations with spectator stands	55	65	55[3)]	65[3)]
6	large games- and sports installations with spectator stands	60	70	60[3)]	70[3)]

1) No reference is made to data permissible immission limit values for further categories of building lands (industrial areas and the like)

2) Relevant plan symbols to be taken from ÖNORM S 5021, part 2.

3) Immission values quoted are only valid, where games- and sports installations are used at night.

Table 6
Planning Values[1)] for Emissions from Locations[2)]

Category according to ONORM S 5021	locations for: A BUILDING LAND	locations for: B GRASS LANDS	equivalent sound level[3)] $L_{A,eq}$ (dB): by day building land & grass lands	by night: building land	by night: grass lands	Remarks
1	Recreation areas (except sports installations), hospitals, spa institutes, old peoples homes, spa hotels in general	Areas for spa & recreational purposes, spa parks, park installations without childrens playgrounds, gardens, cemeteries in rural areas	45	35	4)	Access for estate cars and rescue vehicles to be considered separately
2	Residential quarters[A1)] in solely residential areas with low building density (e.g. with open layout, row homes) schools without open-air facilities, monasteries in general, boarding houses, old peoples homes, garage installations[5)]	Agricultural and forestry utilization, parks, larger cemeteries games- & sports fields without any important noise emission (e.g. golf courses, cross-country ski-runs)	50	40	4)	A1) also in traffic abated zones without children's playgrounds or residential access. installations
3	Agricultural premises residential premises with greater building density[A2)] schools with open air games- and sports grounds, hotels, garage installations[5)]	Market gardens, allotment gardens indoor-baths without open air installations	55	45	4)	A2) Residential areas in general, incl. playgrounds
4	Residential areas with high building density, service & administrative premises Professional trades and industrial goods-production and service premises with slight noise emission, catering enterprises, garage installations[5)] Shopping centres	Games- and sports install. with slight noise emission (e.g. tennis courts, smaller children's playgrounds) Camping grounds Holiday homes f. juveniles Ski lifts (motive elements)	60	50	4)	
5	Work premises for distribution, professional trades- and industrial goods production and service premises exhibition premises filling stations, garage installations, storage yards barracks in general, drive-in cinemas	Smaller games- and sports-grounds with spectator's stands, larger children's playgrounds, smaller open-air baths, riding sports grounds without larger spectator's stands, sewage treatment plants transformer installations[5)]	65	4)	4)	
6	Professional trades- and industrial goods production and service premises Catering premises with garden, dancing and music discotheques	Larger games- and sports-grounds with spectator's stands (e.g. football grounds with spect. stands, larger open-air baths, etc) premises for popular entertainment, skating rinks[6)], gravel works	70	4)	4)	
7	Premises with specially high noise emission	Quarries, shooting ranges[6)] motor sports grounds, model aircraft flying grounds	> 70	4)	4)	

1) near the borders of an estate

2) all examples are held to be exemplifications; according to the allocation categories valid in the Austrian Provinces, some locations may be found both on building land and grass lands

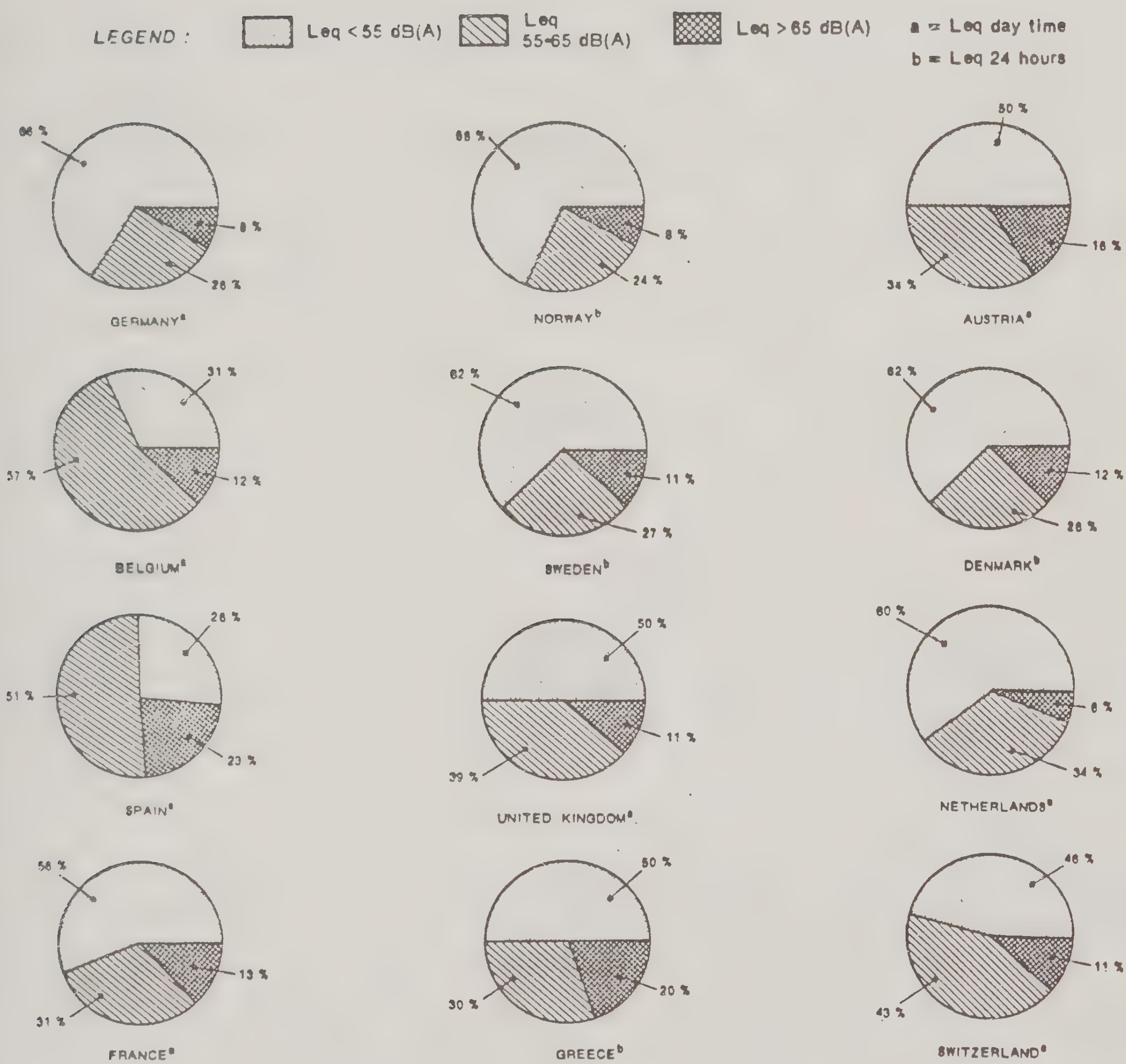
3) with the noise caused by the access- and departure venues

4) observe topical night operations

5) according to topical noise emission, dependent on output and type of construction

6) Approx. values for noise emission of recreational- and tourist installations, see ÖAL-Richtlinie 21 (part 3)

Figure 1
Population Exposed to Road Traffic Noise



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HELICOPTER NOISE

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INTRODUCTION

It is now 35 years since the first experiments with a heliport in central London were conducted by the Ministry of Civil Aviation. Three years later, in July 1955, the first experimental scheduled service was introduced by BEA between the South Bank near Waterloo and Heathrow Airport. It ran for 11 months but was not a commercial success.

The main limitation in growth of helicopter traffic has probably been the lack of helicopter landing and take off facilities which are both close enough to the commercial centres and providing sufficiently good access to make the high cost of helicopter transfer attractive when compared with surface transport systems. The first "permanent" heliport in London was opened by Westland Aircraft in 1958 at Battersea and is still in operation having renewed temporary planning consent at various times. The ten years between 1963 and 1973 saw almost linear growth from something below 2,000 movements per annum (mpa) to in excess of 12,000 mpa, but with this growth in helicopter activity grew major concern regarding the problem of helicopter noise.

Since 1973 helicopter activity in London has remained almost steady partly because of economic constraints, but mainly because of the measures that have been applied to safeguard the environment. Elsewhere helicopter usage has grown, particularly in connection with the oil industry, which despite having passed its peak still accounted for some 36,000 movements at Aberdeen in the financial year ending in March 1987. More helicopters are entering into service all the time, offering the potential to their corporate owners to fly direct from company premises to destinations not available to fixed-wing executive aircraft. There are now significant numbers of flights from hotels for example. Under present planning legislation no planning control is applied to sites used for helicopter landings for up to 28 days in any year.

It is in the interest of all concerned to recognise the needs of the helicopter industry to ensure that when helicopter

growth in urban centres does take place as a result of growth in helicopter usage, that the increased demand for facilities is properly accommodated and that measures are taken to allow the industry to develop, but not at the uncontrolled expense of the environment.

Noise control is now as important as safety for the expansion of helicopter usage. In a discussion on helicopter operations from Urban Heliports [1] which dealt with economics, safety and other factors concerning heliport facilities it was stated:

> "However, by far the biggest factor which needs to be taken into account when looking at a potential heliport site is its environmental impact."[1]

What can be done? The London experience gives some indications on progress that has been made.

Use of Noise Data

Measurements of noise provides data which can then be used either to assess the scale of the helicopter problem, determinte how the environment is changing or assess the success, or failure on the ground of technical changes made to aircraft, or their operation, for noise control purposes. The data are, of course, also useful for planning future environmental noise control measures at the airport. Several kinds of measurement are possible, each developed for a specific purpose and often using its own noise units. Noise monitoring is an effective tool which can give assistance in minimising the detrimental effect of airport development but only if an adequate framework of noise controls are set up and it is clear how the noise data are to be incoporated. In the final analysis, however, it is not the noise levels or noise exposure values that are important, but the effect that these have in the community.

Helicopter Noise Nuisance

Noise and Number Index (NNI)

In the United Kingdom the noise of fixed wing aircraft has

been assessed using the Noise and Number Index (NN1) since the early 1960's. NN1 for fixed wing aircraft is defined:

$$NNI = L + 15\log_{10}N - 80$$

where L is the log average peak noise in PNdB for aircraft operating under the average mode established during mid June to mid September between the hours of 0700–1900 BST. N is the number of aircraft.

For helicopters a form of NN1 has been used:-

$$NNI = L_A + 15\log_{10}N - 67$$

where L_A is the log average peak level in dB(A).

Work carried out by the GLC Scientific Branch in 1976, and the 1983 Helicopter Disturbance Study(2) undertaken by the Civil Aviation Authority both concluded that despite its shortcomings, NNI was the best index for relating helicopter noise exposure to annoyance. Helicopters were, for a given NNI, shown to produce about the same amount of disturbance as fixed wing aircraft although in London the CAA report(2) shows that in areas which suffer noise from both helicopters and fixed wing aircraft the helicopter operations are generally felt to be more annoying.

Taking these results at face value, it is reasonable to use the relationship between NNI and percentage population annoyed as derived by Richards(3), see Fig 1. From Fig 1 it is clear that at even quite low noise exposures a significant proportion of the exposed population will be annoyed by noise. There is little justification for the interpretation often place on NNI values that 35 NNI can be treated as the onset of annoyance. At 35 NNI some 30% of the exposed population would be seriously annoyed, and at 45 NNI, often termed 'moderate annoyance', half the exposed population would be seriously annoyed.

In determining the application for Westland and Trig Lane Heliports, the GLC applied a policy designed to limit noise exposure from helicopter operation to 40 NNI. This is consistent with the DOE circular 10/73[4] which advises that

no major new residential developments should be permitted where aircraft noise exposure exceeds 40 NNI. In the United Kingdom the use of helicopters has not exceeded 40 NNI, except on rare occasions so no check has been made to ensure that, at high noise exposure, the response to helicopter noise is neither more tolerant or intolerant than that established for fixed wing aircraft.

Equivalent Continuous Sound Level (L_{eq})

As an indicator of social response to aircraft noise, NNI has been severely criticised for some years now. One of several major criticisms has been that its calibration against annoyance, derived from surveys in the Heathrow area are now out of date since the pattern of use has altered substantially since the last major surveys in the mid 1960's. In 1985 the United Kingdom Aircraft Noise Index Study report [5], known by the acronym ANIS, was published. Amongst the major conclusions of ANIS (which are still being debated) is that 24 hour 'Equivalent Continuous Sound Level' (Leq) offers a better correlation with various measures of community disturbance than NNI.

L_{eq} represents the steady noise which, over a given period of time (24 hours suggested by ANIS), would carry the same acoustic energy as the fluctuating noise which may be heard. Mathematically L_{eq} is expressed

$$L_{eq} = 10\, Log_{10} \left\{ \frac{1}{T} \int_{t_1}^{t_1+T} \frac{p_A^2}{p_0^2}\, dt \right\}$$

Where P_A is the unsteady sound pressure being considered for a time T, (P_o is a standard reference pressure).

SEL, also referred to in this report, is the steady sound pressure level of one second's duration which would carry the same acoustic energy as a particular noise event. The mathematical expression of SEL is therefore simply obtained by replacing "T" with the reference time t_o (which is 1 second):

$$SEL = 10\, Log_{10} \left\{ \frac{1}{t_0} \int_{t_1}^{t_1+T} \frac{p_A^2}{p_0^2}\, dt \right\}$$

The use of SEL and L_{eq} brings into consideration the

duration of the noise which NNI does not but gives a lower weighting to the effect of increasing the number of events, movements in the case of helicopters. A doubling of movements could, all other things being equal, give rise to a 3dB increase in L_{eq} and the equivalent of a 4.5dB increase in NNI. The CAA's Helicopter report[2] concluded that although NNI showed the greatest correlation with reported disturbance, the 12 hour L_{eq} was only slightly inferior.

There is therefore, a general trend in recent years to move towards adoption of some form of L_{eq} for the noise index in all forms of aircraft noise assessment for environmental purposes. In the case of helicopter operations involving significant time spent in "hover" the use of L_{eq} rather than NNI has substantial influence on the estimated noise impact.

Annoyance and L_{eq}

Unfortunately, there is no objective unit of annoyance, but ANIS gives a relationship between noise and the responses to various questions about annoyance which leads to the summary of responses to various L_{eq} values in Table 1. All the social responses to aircraft or helicopter noise discussed in this section refer to residential population. A major consideration in central London must be the effect on business and commercial populations. The effect on schools, hospitals and other noise sensitive areas including tourist centres must not be ignored. There is no reliable social survey data relating to these other uses, with the possible exception of schools where some assessment of the disturbing effect of aircraft noise has been made[6]. In the absence of further studies it is probably best to assume that office workers will respond in much the same way as residential population, although offices which are air conditioned may reduce the noise levels heard. Open air tourists centres may be more susceptible since all survey results are meant to relate to the reaction 'inside' a building to the external noise levels. In each case noise from helicopters is likely to be heard in areas which are normally screened from other ambient noise (such as traffic for example) making the potential 'intrusion' from helicopter noise much greater than other non-aviation sources.

Helicopter Noise Certification

Certification noise tests are conducted under the Civil Aviation, The Air Navigation (Noise Certification) Order 1986[7] which specifies exacting meteorological and operational conditions which are rarely, if ever, those pertaining during day to day operation in London. The purpose of the tests is to determine the emission of a particular make of helicopters against appropriate international noise standards using agreed test procedures. It must be stressed that it is not sufficient for planning purposes to rely on the achievement of the noise values as specified in the noise certification regulations as these are dependent on the weight of the helicopter and give a potential variation of 20dB between the quietest and must noisy certificated machines (Fig 1). There is no point in trying to repeat this sort of assessment during routine monitoring but the results obtained by the certifying authorities are useful for heliport planning. For the assessment of heliport proposals, the certificated noise level together with an appropriate 'operational adjustment' is required in order to take account of the expected mode of operation for the particular installation.

For certification puposes noise from new helicopters is measured for 'Take Off' at two symmetrical points located 150m to the side of the ground projection of the flight-path at a distance of 500m from the 'Take Off' point (shown schematically in Fig 2). Similarly, pairs of monitoring points located 150m and 120m below the flight paths are used for 'Flyover' and 'Approach' noise respectively.

Application to Helicopter Noise Control in London

Over the last twenty years or so a number of unsuccessful applications have been made to provide a heliport, the most recent is the Star Aviation Ltd proposal to develop Chambers Wharf[8] on the south side of the river in Bermondsey. In common with many other applications, the possible environmental noise problems of a heliport played a substantial part in influencing the recommendations made to the Secretary of State by the planning inspector. In particular the letter of decision quotes paragraph 297 of the

Inspectors report

> "I have come to the overall conclusion that the proposed heliport, by virtue of the noisy activities it would generate, would detract from the amenities of peace and quiet which residents might reasonably expect to enjoy and it would set back the objectives of regenerating this part of Docklands. When viewed within the framwork of Circular 14/85 I consider that the heliport operations would adversely affect the local environment and, coupled with the impact on regeneration, cause demonstrable harm to interests of acknowledged importance. In reaching my conclusions I have had regard to the importance attached to providing a special service for the business interests of the City, and the provision of up to 11 jobs."

Noise must therefore be a major consideration in the design and location of any heliport.

Trig Lane Helistop benefited from a temporary planning consent which paid cognisance to the then planned development of the City of London Boys School on the adjacent site. Close proximity of helipad and the newly built school were not ideal, the helipad therefore ceased operation agreed with the City Corporation and the Greater London Council.

In 1976 the former GLC introduced its own helicopter classifcation by using two groups, "List A" and "List B", for regulating operation at Battersea Heliport. At the heliport, a limit was set on the overall number of movements with a small quota for the noisier "List B" types only. A similar approach was used at the Trig Lane Helistop where operations were restricted to "List A" types. "List A" helicopters are those capable of producing noise levels of less than 81 dB(A) at a point 150m from the take off point under normal operational conditions. More recently, a revised classification of helicopter types was suggested by the former GLC[9]. This makes use of the ICAO noise assessment procedures, now included in noise certification requirements, to make a more general statement to classify helicopter types without resource to further testing by the

planning authority each time a new helicopter is introduced. The classification, which is summarised in Table 2, does not duplicate the objectives of helicopter noise certification but uses the certification test procedures and results to provide a useful basis for planning noise control strategies.

Noise Emission and Environmental Capacity

It is clear from the preceding discussion on noise nuisance that it is the noise emission which is important to the community. Noise emmission depends not only on the noise emitted by the helicopter under idealised conditions as expressed under noise certificate procedures but also in the flight characteristics (engine setting, climb angle etc) of the helicopter and the layout of the surrounding area. Predictions of helicopter noise are now possible using base data derived under operational conditions relevant to a proposed heliport. LSS is continally adding to its helicopter noise data base in order to be able to make predictions of noise exposure. The data together with noise certification information makes an effective basis for helicopter noise control by limiting the operation of a heliport within the "environmental capacity" of the surrounding area.

Operations which take place near a community must be governed with the specific existing and long term needs of that community in mind. Future developments in helicopter technology and the scale of operation should be catered for, so should the possible changes in the community itself. Environmental boundaries must be identified and expressed in a way which can identify for aircraft operators the scope for expansion whilst safeguarding the amenity of the area. It is just not good enough when a heliport has been developed in an area which is not susceptible to noise for the local authority then to permit unsuitable developments nearby. Similarly, a heliport which has been developed with a clear statement of what level of noise is tolerable should not expect to be permitted to increase its level of activity or to introduce new helicopters which, even though they may be noise certificated, could produce higher noise emission. Each heliport has, with its surrounding community, an "environmental capacity" which must be recognised and protected whether the heliport is expanding into the

community or the community expanding towards the heliport.

Conclusion

There is a sad history at Britain's major airports of development, both of the airport itself and the surrounding area, to race ahead until the environmental conflict becomes almost intractable, it is important that the same should not occur for heliports. A better approach, available early in the development planning process, would be first to decide what is an acceptable heliport noise environment for the area, or more specifically determine an acceptable noise exposure boundary. Wherever people and noise come together then some of the people will be annoyed to a greater or lesser extent, so it is very unlikely that nuisance can be completely avoided. However, it should be possible to draw a boundary within which a given noise exposure would probably be acceptable. Experience at London's heliport has demonstrated that noise control can be effected by use of standard noise emission data in conjunction with movement quotas provided that other developments in the area recognise the established environmental boundary for the heliport operation.

REFERENCES

1 J P Durrant. Helicopter Operations from Urban Heliports. RAES - Future Transport Helicopter Symposium. 20 January 1987.

2 Atkins, CLR., Brooker, P, Critchley, JB. 1982 Helicopter Disturbance Study: main report. The Civil Aviation Authority, DR Report 8304. 1983.

3 Richards, E.J., Putting a Value on Noise - The Development of an Index which is fair to both Airport Operators and the Public. Journal of Sound and Vibration 49(1),pp.53-73, 1976.

4 Planning and Noise, Department of The Environment Circular 10/73.

5 Brooker, P., Critchley, J.B. Monkman, D.J. Richmond, C., United Kingdom Aircraft Noise Index Study: main report. The Civil Aviation Authority, DR Report 8402. 1985.

6 Crook, Langdon. The effects of aircraft noise on schools around Heathrow Airport. BRE CP 13/75

7 Civil Aviation, The Air Navigation (Noise Certification) Order 1986. SI 1986 No. 1304.

8 Town and Country Planning Act 1971 - Section 37
Appeals by Blue Star Ship Management Ltd.
Application No S/85/80/ and S/85/79
Decision letter 22 January 1987 and Inspector's report 9th October 1986

9 Greater London Council
Helicopter Operations in London
Report of Planning Committee (P1234,14/6/84)

10 ICAO Committee on Aircraft Noise No. 6, Montreal, Canada.

Table 1 Attitudes to various 24 hour Leq noise exposures

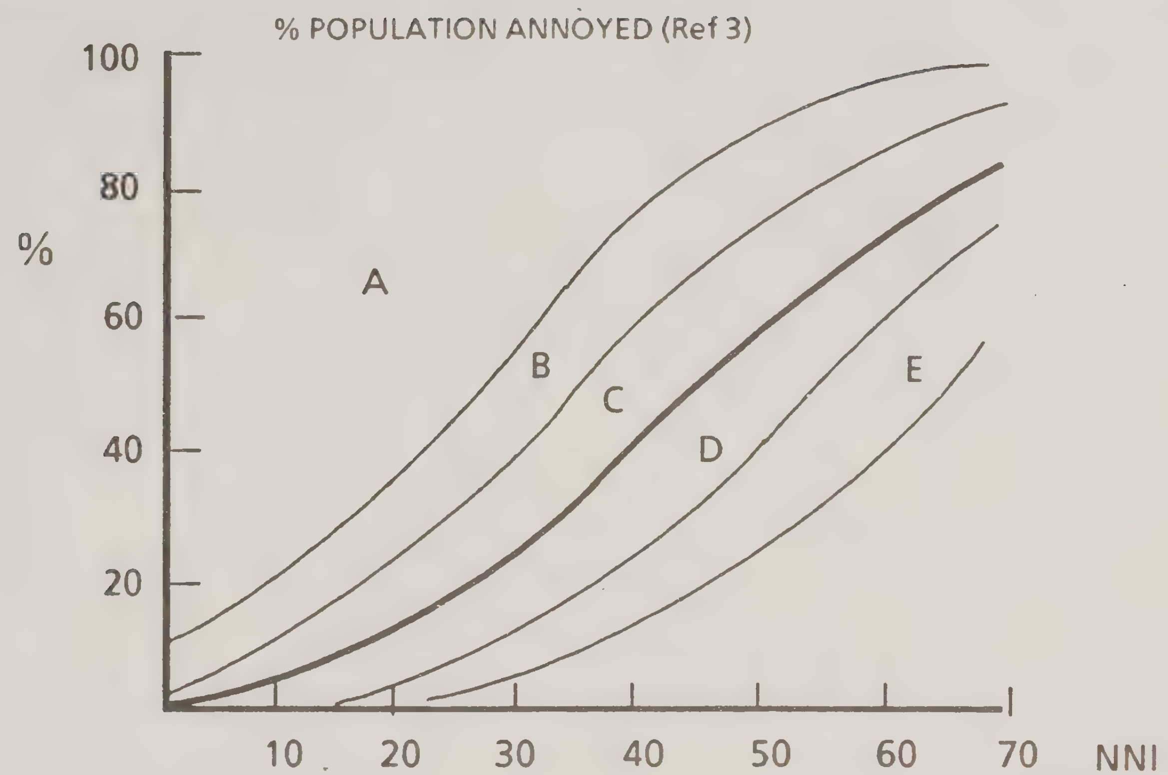
Percentage of Population	"At least a little bothered"
25	<50 dB(A)
50	50 dB(A)
75	60 dB(A)
90	65 dB(A)

"Very much annoyed"	"Most bothersom noise"	"Not acceptable"
57 dB(A)	49 dB(A)	55 dB(A)
67 dB(A)	58 dB(A)	62 dB(A)
77 dB(A)	61 dB(A)	69 dB(A)
83 dB(A)	67 dB(A)	74 dB(A)

Table 2 Helicopter Noise Classification used by the former GLC

GLC Noise Category	Take Off (Noise Level in EPNdB*)	Landing (Noise Level in EPNdB*)	Flyover (Noise Level in EPNdB*)	Equivalent Old GLC Listing
1	Level 85	Level 89	Level 88	"List A"
2	85 Level 90	89 Level 94	88 Level 93	"List A"
3	90 Level 95	94 Level 99	93 Level 98	"List B"
4	95 Level 100	99 Level 104	98 Level 103	"List B"
5	Level 100	Level 104	Level 103	"List B"

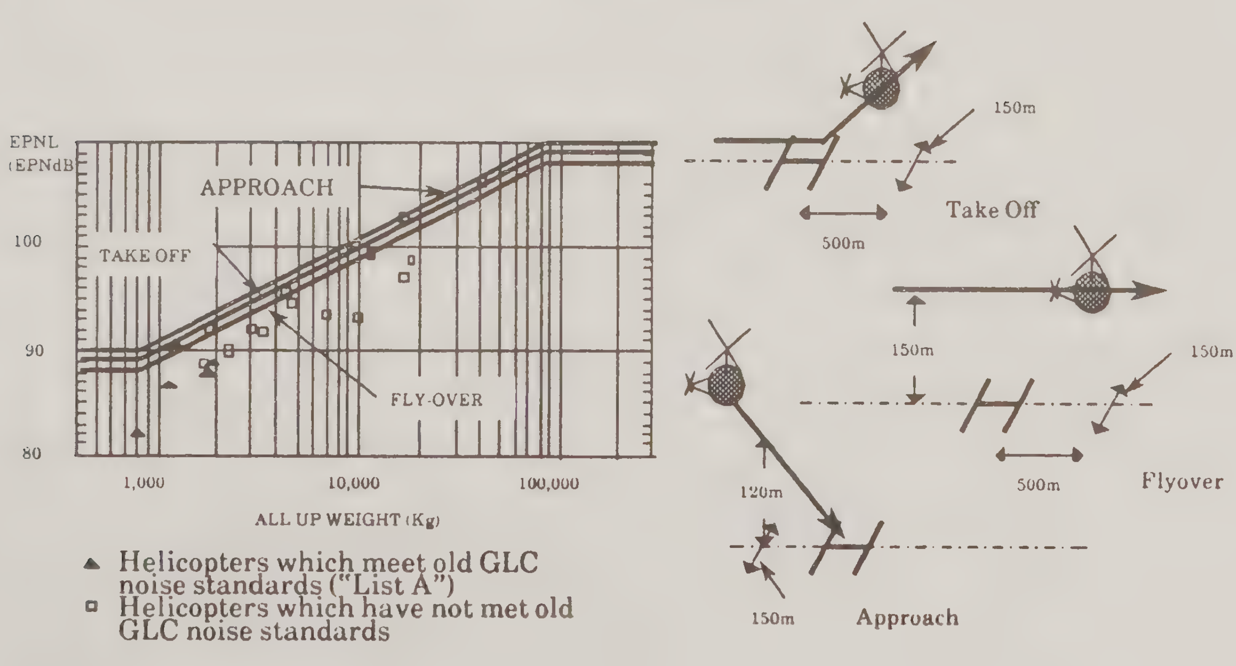
*From ICAO CAN6(10) test procedures



A Not annoyed B A little annoyed
C Moderately annoyed D Severely annoyed
E Finds noise difficult to tolerate

Fig 1

Fig 2 Helicopter Noise Certification Regulations (7)



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SURVEYING TRANSPORT NOISE

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As the Chairman has said I have had over thirteen years with the Greater London Council Scientific Services, and working with John Simpson in the London Scientific Service. I have specialised in those thirteen years in dealing with road traffic noise so I won't make any apologies for dealing mainly with road traffic noise problems this morning. But what I hope to do is to highlight some of the problems in what may seem a simple task of mounting a noise survey. In the thirteen years I have seen the results of surveys of transport noise presented, even at public enquiries, that have not been well thought out - "just go and measure it and we'll worry later on about how we present the data." I hasten to add that none of my surveys and none of the studies in LSS were ever done that way were they John? But in fact it is a problem and I have seen much effort and waste of resources and money in not thinking the whole thing through properly.

As I said I am talking mainly about road traffic noise but much, if not all, of what I am going to say this morning will apply to other types of noise surveys. Road traffic, Dr. Laing has already said, is by far the most widespread source of noise in London and there can be very few people in the country as a whole who are not affected by it. It seems that in most western countries nowadays the average citizen considers it perfectly fair and reasonable to own and operate a private motor car. However, what he considers most unreasonable and unfair is that other misguided individuals should also own motor cars and be allowed to drive past either his house or office and make a noise which disturbs him, either when he is asleep or carrying out recreation activities or trying to concentrate. It is fact, however, that, as more and more people drive cars, lorries and buses, the level of noise will increase. It will not only increase but, in fact, it will spread to previously quiet periods of the day, such as early morning and evening, and, in fact, into quiet streets. I drove yesterday down here and followed a British

School of Motoring car, and thinking about the statistics written on the back of it - I think it said something in the region of 20 people per minute passed their driving test with the British School of Motoring. This isn't an advert but it started me thinking that in fact that is going to be 20 people per minute just with BSM - thats 1200 per hour. In an 8 hour day that's 10,000 people, 50,000 per week, all going to be presumably driving cars at some time, the manufacturers will hope only cars, and creating more and more noise and more and more pollution due to increased use of fuel. It's too late to rush out and buy your BP shares - they shut at 10 o'clock.

But society does need a good road network because of commercial needs; it needs a quick link intercity; pleasure needs; we need to get from A to B very quickly. All this has a detrimental effect on the environment and means that there is in increasing need to monitor noise.

So we are going to mount a noise survey. Why? Is there a specific problem? Why does the problem occur? When does it occur? How are we going to measure it, what equipment are we going to use and what units do we use to measure it? all questions that must be addressed prior to setting foot outside of the office and mounting the survey.

Let's look at the questions one by one. Is there a specific problem? Are you responding to a specific complaint from a community group or residents or are you just trying to gather data? To give you an example, in the context of my present job dealing with the London lorry ban, we have to address the problem, why are they such a nuisance, why do people complain about them? If I can give you an example, up there are the difference in frequency characteristics, the characteristic of the noise, between a typical car and a typical truck. You can see, apart from being noisier generally, a greater level of noise at the low frequency end - there is much more of low frequency content in the lorry than there is in the car. Why is that a problem? It is the low frequency that, in fact, people sense, people feel as a vibration; it is this low frequency noise that impinges on a dwelling, causes loose fitments to rattle and ornaments on the mantlepiece to rattle. An added problem with that is

that, when you look at installing double windows, which, as has already been said, is one of the solutions to reducing noise, we can see that at the low frequency end, even double glazing does not have a dramatic effect. If I superimpose two graphs, you see that installing double glazing at the low frequency end, which is the problem end as far as people experiencing heavy goods vehicles are concerned, double glazing does nothing. That is one example of looking at what the specific problem is prior to mounting the survey.

I'll give a couple of examples, although they are not actually based on transport noise. We had a situation where a resident was, in fact, complaining about a high pitched noise. There were several visits by members of staff and Local Authorities and no-one could hear this particular noise. We installed monitoring equipment and on doing frequency analysis we found out that, in fact, there was a high frequency noise problem there and in the end it was traced to a freezer shop across the road. Also we had a situation where there was an old lady who lived alone at the top of a block of flats and had complained to the Local Authority on numerous occasions about the state of decoration in her flat. She was a lonely old lady and just wanted to talk about the problems. She had complained about a banging noise in the middle of the night and being sprayed with water while she was in her bed. People made several visits there, couldn't see any problem and put her down as being a lonely old lady and in fact a bit of a crank. However, when we fully investigated - in the LSS this was - the situation, we found that the central heating venting system was venting in the middle of the night, there was a problem with the heating system and the vent pipes were, in fact banging on the loft space on the joists and sending down a shower of plaster dust from the badly decorated roof. The reason for telling you that is that we should not assume that our ears, in fact, are perfect if we get complaints. We should always thoroughly investigate the problem.

When does the problem occur? If we go out and measure on the off chance, it's a certain gentleman's law that you will pick the wrong day of the week. The number of times I've heard "Oh you should have been here last Thursday" or "It

only happens on a Tuesday afternoon" is always the problem. So research the problem, ask the complainant when the problem occurs. It is simple advice but it is so often forgotten and it will save time and money. If it is an intermittent problem, then we have to start looking at long term monitoring and installing equipment, which I will come on to a little later on. It is not only the day of the week that we are interested in but also the time of the day and the season of the year. Certainly, in terms of road traffic, there is a great seasonal variation in traffic flow. In heavy goods vehicles for instance, prior to the Christmas season and use of docks etc. there is a great seasonal variation. You ask anyone who drives into town in an ordinary motor car the difference between the traffic flows during school holiday period, for instance, and when the children are back at school - there is a tremendous difference. So beware of the seasonal peaks when you are monitoring.

The general road traffice noise, however, you should avoid monitoring during peak hours. In fact, the method used to assess peoples' eligibility for insulation under the Land Compensation Act, which is a calculation of road traffic noise, specifies that when going out to monitor noise, you should in fact monitor between 10 a.m. and 4 p.m. The reason for this, in the idyllic situation, is that this sort of thing occurs. You get a build up in the early morning to the a.m. peak - here shown as 9 a.m. - then this noise plateau between 10 a.m. and 4 p.m., building up to the p.m. peak and then dropping away in the evening. This is a rather simplified situation but that is the advice, to go out and monitor between 10 a.m. and 4 p.m. In the real world studies have shown that this sort of thing goes on, so in fact the real world is not perfect. Perhaps you could say you are getting some of sort of morning peak and some sort of evening peak but it is very, very difficult and, as I said earlier on, with the increase in motor transport, we are going to have a shift away from this peak situation and have increasingly noisier times of the day - we are going to lose the early morning quiet and the early evening quiet.

We've looked at the problem and we've looked at the time of day - what units should we use to measure this noise problem? There is a very good - I know it's now defunct,

The Noise Advisory Council, and this is a photocopy - but if you can get hold of a copy, there is a very good publication, "Noise Units" by the Noise Advisory Council that goes into the detail of which units are available, what indices should be used for different occasions and different studies. If I can give you some idea of the proliferation of the noise indices, the scales and units that in fact face you when you are mounting a survey - these are just a few. I shan't go into any of them now, save to say that for road traffic noise we use a unit of d.b.a., we use a percentile value of L10, which is the noise exceeded for 10% of the time and it is normally expressed over an 18 hour period, that's 6 a.m. until midnight, and it is this L10 18 hour d.b.a. That is the unit that has been found to correlate best against the human reaction to road traffic noise, so that is the unit that has tended to be used in road traffic noise studies. The reason for, in fact, using the L10 - the level exceeded for 10% of the time - is, in fact, that road traffic is a continually fluctuating noise source - it is not a steady source - and, therefore, a single figure cannot adequately describe the noise as a whole.

Now, the problems of using d.b.a. - it's the accepted unit for road traffic noise. I've already said that in heavy goods vehicles surveys it's the low frequency content that is the problem. It's the low frequency content that people react to and cannot be negated by double glazing but this very d.b.a. unit that, in fact, vehicles are measured by does not take into account the low frequency content of the noise. If I can show you a linear recording of a heavy goods vehicle going past and then show you what that vehicle looks like when A weighted, you can see that, in fact, the A weighting does not reflect the problem that exists at the low frequency end. There are in fact other weightings that can be used - in fact, if you were to use the C weightings, you see it responds much better to the low frequency problem and there is a move afoot, in fact, to get the d.b.c, used when dealing with heavy goods vehicle noise.

This brings me on to test procedures. How are we going to measure a noise, is there a specified procedure? The specified procedure, if it does exist, is not always perfect but if it is there we are duty bound to use it. We have to

use it, particularly if we are going to the use the data that we collect as any sort of evidence in an enquiry. To go on from the use of d.b.a. and the heavy goods vehicle problem, the EEC have a test procedure for measuring moving vehicles - not only heavy good vehicles but anything from a motor bike up to a juggernaut. The method is very simple on paper. It consists of driving a vehicle between lines AA to BB with microphones placed at set distances away. When the front of the vehicle reaches the first line, the driver puts his foot flat down on the accelerator and drives to line BB. When the rear of the vehicle passes line BB, he takes his foot off. This is done three times in each direction. The worst noise level monitored in d.b.a. at the microphone is then taken, 1 d.b.a. is subtracted - why for the life of me I do not know - but 1 d.b.a. is subtracted and that is your test result. I have already mentioned the problems with d.b.a. from heavy goods vehicles so, therefore, it is not an ideal test procedure. We have EEC legislation that specifies, as Dr. Laing has already said, certain maximum noise levels for vehicles. If we are still measuring them in d.b.a. then we are not really showing the subjective reaction towards the noise levels of those vehicles. There has been a vehicle in existence for some time put together by the Transport & Road Research Laboratory. It's quite a heavy vehicle - I think it's about ten years old now - and in fact it reduced the drive-by noise levels by about 10 d.b.a. - a significant reduction. In the early stages of introducing the night time and weekend lorry ban we, in fact, carried out a series of subjective studies that I will mention briefly later on and, in the course of those tests we hired that vehicle and drove it past a panel of observers and, although the absolute noise level was, in fact, very similar to an ordinary car, the characteristic of that vehicle was such that the low frequency content was still there and people, in filling in their questionnaires, in fact, picked that out as still being a heavy goods vehicle. So there is a problem with the test procedures but, basically, if there is a test procedure we should use it.

The other problem with that particular test procedure is that it does not show the component problem of vehicle noise. The noise comes from a lot of sources on a particular vehicle and in just driving it through there you are not

picking out some of those, perhaps problematic, components. For instance, in an inner city, if you have heavy goods vehicles flying through a city, particularly at night time, the problem is not going to be noise from the cooling fans, because you will probably find that if it is a thermo fan it is not in operation for the majority of the time. The problem is more likely to come from the air brakes, possibly hissing when it comes to traffic lights or a junction, not taken into account by this test. I've listed there some of the sources of vehicle noise.

Measurement leads me on to instrumentation. I'm going to duck this subject very quickly, looking around me, because there are a lot of stands here with people selling the instrumentation. I will say that the theory of measurement and measuring instruments is a very complex one but, however, all of the pieces of equipment that you are likely to use will basically consist of three components - a transducer to convert the sound pressure signal into a usable form, some sort of recording device and then some sort of analysing device. The most versatile transducer that we are probably all aware off is a portable sound level meter, which incorporates various weightings - normally the a weighting is on a sound level meter. If you are going to use this equipment, you should look for a good piece of equipment with a dynamic range of about 40 d.b.a. What I mean by dynamic range is that on a scale you will see a range of 10 d.b.a. In fact, if you overload or go off the scale underneath when recording noise, you should not waste that signal - you should be able to still record that signal - and the range that it is capable of doing above and below the scale that you see there - you are looking for range of about 40 d.b.a. You should be able to measure noise I would say between 30 and 140 d.b.a.

The sort of things that may influence the choice of equipment first of all is, are you going to install automatic equipment or are you going to have a man survey? The decision as to that is probably based upon the problems. Do you need observations? It is pointless to put in a piece of equipment to monitor noise levels along a road if there is a problem at a certain time of night on numbers of vehicles or types of vehicles and you are going to require people to be

there in order to distinguish what sort of vehicle is going past at a given time. The equipment is becoming more and more sophisticated and in some instances you are able to actually, on analysis, pick out what type of vehicle it was given its characteristic but I would suggest if you have a particular problem it is worthwhile, at least some of the time while you are monitoring, getting somebody there to observe what is going on.

Another aspect is whether you are going to monitor long term or short term. If long term, then almost certainly you are going to require the automatic equipment and if short term, then you have to look at the length of time you are going to sample while you are there. The length of sampling time required to produce a meaningful result really depends upon the nature of the signal being recorded and, in the case of road traffic noise, the shortest sampling period that can be related to the vehicle flow rate. I would recommend that, when monitoring in short term measurements, you, in fact, do not measure for less than 20 minutes in any one hour. The calculation of road traffic noise that I have already mentioned gives a shortened measurement procedure for obtaining an 18 hour noise level, so if you want to know what the noise level is likely to be over an 18 hour period, you can go out between 10 a.m. and 4 p.m. and monitor for three consecutive hours, take the average, again take off one - I don't know why again but it's to do with the accuracy of the equipment - and that is your L10 18 hour d.b.a.

I have a list of practical points to consider. Do calibrate the equipment before and after measurement. This is very important to make sure your equipment is functioning properly. Measuring afterwards is as important, because you have to know whether your piece of equipment has fluctuated. Keep a note of any changes in any instrument switch positions. Again important - I've seen several surveys where, particularly where the boss comes along and twiddles with the knobs while you're not looking, often you will find you are 10 d.b.a. out either way. Perhaps if you do not know what the noise problem is there, until an embarassing situation in an enquiry where you give your evidence and you find that it is 10 d.b.a. different to your opponent's and you've got some explaining to do. Make careful note of the

measurement. This is very important because of the reflections you can get from buildings, how close you are to the noise source etc. Avoid unwanted noise sources. This is particularly important when measuring noise sources in shopping areas and things like that - people come up and shout into microphones, ask whether you are going to take their picture etc. If possible turn the machine off because it does make a difference if people start shouting. Do make measurements under typical conditions. There you have to address the problem of what is a typical condition, what day of the week you measure etc. Do not obscure the microphone. If you are going to have people out on a noise survey, again this is obvious, but don't stand around the microphone, don't stand between the microphone and the noise source because you will act an an absorber. You will also act as a reflector if you stand very close to the microphone. Don't measure in high winds and do use the microphone wind shield anyway. Don't make mesaurements in the rain. You will find that, when you are talking about road traffic noise the frequency content of your noise does vary with the wet road surface.

Contingencies for surveys. I think a good piece of advice is always think what could go wrong and then assume it will. I'll give you a couple of examples. When we were monitoring Concorde, when it was first coming into service, this was quite a labour intensive exercise, because we had to mount monitoring stations along the flight path. We gained information from Heathrow as to which runway - I don't know whether you know Heathrow at all but in fact it has two parallel runways and they all come in on one runway during the morning until 3 p.m. and after that they change runways and use the runway. We were going out in the morning, we found out which runway they were using, we positioned all the troops and the equipment there and we were waiting for Concorde to come in. Suddenly we find that Concorde has already landed on the other runway. People were playing games with us on that particular occasion. In the end what we had to do was we got short band radios and we listened to the pilot from Concorde actually coming in and when we heard people were all coming in on 10 left and then Concorde came in and the tower said "OK clear to land on 10 right", it was a question

of all in your cars and set up equipment on the other side, so we had prior warning.

On one of the helicopter surveys that John spoke about, we had problems about the London Battersea Heliport being very close to a large number of tower blocks, so we wanted to find what the impact was on the residents of that tower block. So we set up equipment. We also wanted to know, because of this noise certification subject, what the noise levels were for certain types of helicopter. It so happened that because the buildings shielded Battersea Heliport, in fact, where people were suffering the noise due to reflections and we were actually monitoring, we could not see the types of helicopter that were taking off. Therefore, it was important to get somebody with a walkie talkie down alongside the helicopter pad to actually identify each individual event.

Subjective surveys as well. If you are thinking of actually mounting subjective surveys to go along with any noise surveys, it is very important to word questionnaires properly. It is a very difficult subject and I would suggest that you call in experts on social surveys to word those questionnaires. Basically, looking at revising the noise insulation regulations, one of the points in our brief was to look to see whether, in fact, we should change from the d.b.a. to the l.e.q. In doing that we spoke to some of our European partners and the word that was coming across there was that, perhaps, they weren't too happy with the use of l.e.q. d.b.a. but they were not willing to change just for change's sake. As a Committee we, in fact, could not see any reason for changing, with all the inherent costs, from d.b.a. to l.e.q. I think one of the dangers of using l.e.q. is that if you use the l.e.q. to monitor railway noise and road traffic noise, there is a great danger of, in fact, just doing a logarithmic addition and saying that is your total noise picture at the end of day. What we have to keep in mind is the different characteristics of this type of noise and, therefore, if we go over to just one unit, there is a danger of actually losing that aspect.

Do you want me to go on to talk about contranoise, sorry antinoise? Contranoise is in fact a company that has been

set up by SRL, who I visited in the course of my attempts to quieten vehicles and introduce quieter vehicles. It's something you read about. It seems almost beyond belief until you actually go and see the research that's being done at the various universities and organisations around the country on feeding back to noise to cancel out the noise problem. It works. It works on stationary plant, it works very well when you have a repetitive signal. In terms of actually fitting this on to a vehicle, I see three problems. I see the problem of the fact that a moving vehicle, a vehicle where one has a foot on the accelerator and that influences the noise characteristic, the noise emission, at present the equipment I have seen will not react quickly enough to dampen down that noise, to reduce the noise. I see a second problem in the size of the equipment. Perhaps with new technology going on apace that will not be a problem for too much longer but certainly the equipment that I have seen takes up quite a lot of space and where you are going to fit that on the vehicle and how much it will weigh are very important. Thirdly, and not least important, is the robustness of that equipment. If you are going to put this sort of feedback equipment, which must involve use of microphones etc., onto a vehicle that not only goes on road but goes off road over very bumpy and dirty ground, you have to make sure that it is robust enough. I think it is a very exciting concept. I hope I see it introduced into vehicles in my lifetime. I wonder.

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THE GAS INDUSTRY CONTRIBUTION TO CLEAN AIR

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SUMMARY

Gas is a form of energy that can be supplied to the consumer without adversely affecting the environment in a significant way. Its use has made a positive contribution to air quality that has included not only decreased smoke and sulphur dioxide emissions but also lower emissions of nitrogen oxides than might otherwise have been the case.

The contributions to photochemically active hydrocarbons and to greenhouse gases, from natural gas supply and use, are very small.

Proven reserves of natural gas, and the application of conservation measures should ensure a reliable supply for more than 50 years. The environmental aspects of gasification for integrated combined cycle or substitute natural gas production, are discussed.

Proposals for changes in air pollution legislation are expected over the next few years. It is important that any emission limits applied to the use of gas are not so strict as to discourage the use of this environmentally advantageous fuel.

1. INTRODUCTION

Over the past few decades the more visible and obvious types of air pollution, such as black smoke and smogs, have decreased and the less obvious types of pollution have become much more widely studied and their causes and effects debated. The interactions between the pollutants and their effects on different receptors are known to be extremely complex and often involve water and land as well as air. The acidification debate illustrates many of the complexities in atmospheric chemistry, precipitation, water and soil chemistry and the impingment of other factors not directly attributable to pollution. It has also brought the realisation that air pollution is not restricted by national boundaries but also has the potential for generating problems on an international scale. Indeed some aspects of air quality - the 'greenhouse effect' and depletion of the ozone layer - are on a global scale.

As the scale and complexity of the interactions increase there is the danger of understating what has already been achieved in air pollution control on the local and national scale. One of the factors that has made a significant contribution to that improvement in air quality is the use of gas as a fuel.

2. GAS AND THE ENVIRONMENT

Any positive effects of natural gas on air quality would be of little vlaue if they were at the expense of other aspects of the environment. Happily this is not the case. Great care is taken with the supply of gas, from its natural reservoir to the burner, to ensure that environmental aspects are carefully considered.

In this European Year of the Environment (EYE) some aspects of that story have been drawn together in a short illustrated publication [1] entitled "Gas and the Environment" prepared by Cometec-Gaz, an organisation representing many of the European gas industries. Its visual material provides a useful supplement for this written paper.

2.1 Exploration and Production

The exploration and production phases for gas are carefully controlled to minimise environmental damage. Measures taken during the drilling stages onshore prevent contamination of surface water and groundwater. Many drilling sites have two drainage systems to isolate clean and contaminated water. Approved disposal arrangements are made for contaminated water or any surplus drilling mud. Much effort has gone into recycling mud or minimising the volumes requiring disposal, through the use of cyclones and centrifuges or by precipitation methods[2]. Precautions are also taken to minimise noise nuisance and gaseous emissions.

Exploration and production activities offshore are also controlled, in that there are limitations on the quantities of specific substances that may be used or discharged. Legislative requirements vary but monitoring of the sediments and benthic fauna may be required up to 6000

metres from the rig and work of that type is undertaken by our Company.

2.2 Terminals

The sites chosen for shore terminals are sometimes near to quiet rural villages or to some area of special scenic or scientific interest. Consultation procedures must be initiated well in advance of the development in order that mutually agreeable proposals can go forward. This usually requires some form of environmental impact analysis. The sites can be up to 100 hectares in area and, for safety and other technical reasons, they are sited close to the shore. The options are usually limited by the need to minimise the length of undersea pipelines, the suitability of the seabed and coast geography for a pipeline landfall, the size of the site, and the coastline that is already protected or used for industrial purposes.

However, when the consultation procedures have been successful and the terminal is operational it is extremely effective as a supply route for energy, as some Society members will have seen during the visit from Conference last year. A 100 hectare terminal could be treating a throughput of 112 million m^3 of natural gas per day i.e. energy transmission equivalent to a 1000 tonne train of coal every ten minutes. Combined with the transmission system it is a route that is effectively free from disturbance during periods of severe weather that can affect the transport of other fuels by road, rial and conveyor belt systems.

Natural gas which has a significant sulphur content is treated to remove the sulphur before the gas enters the transmission system. The purification can be carried out without significant effect on the local air or water quality[3].

2.3 Transmission

The development of transmission systems for gas involved the laying of large diameter high pressure pipelines over a wide variety of terrains. The reinstatment techniques used have been carefully studied to ensure that not only agricultural land will return to its former state but also that land where

specialist reinstatement is required, such as heathland. In comparison with the transport of other fuels the gas transmission system is very efficient, for example the amount of gas flowing through the UK system on a peak day is equivalent in energy to 129 Sizewells!

Compressor stations are required at intervals along the pipeline to maintain pressure. In the UK they are usually about 40–50 miles apart and have several centrifugal compressors each driven by an aircraft type gas turbine. Both design and cladding methods reduce the noise emissions from the generators, power turbine, compressor and the pipework, to values that are unlikely to cause nuisance. The visual aspect of a station is considered important in gaining local approval and the design often involves the use of striking colours.

2.4 Storage

Storage is necessary to meet both diurnal and seasonal viriations. The gasholder is still to be found in some urban sites and indeed a few are preserved as examples of industrial architecture, but low profile high pressure storage, sometimes underground, now provides much of the diurnal storage.

In order to cope with the variations in gas consumption over the year, and to guarantee security of supply in the event of failures, it is necessary to have strategic storage. One option is to control gas fields so that the flow can be adjusted as required. A gas field may be used in the winter only, e.g. the Morecambe Field; another option is to use a depleted field, such as the Rough Field, which is filled in summer and depleted in winter. Such systems give enormous additional storage with very little additional environmental impact.

There are two forms of storage whose locations are determined by the desired geology, i.e. storage in salt formations and in aquifers [2,4]. By leaching cavities within the salt in a controlled manner, underground caverns of the required shape can be formed. Examples are found at Hornsea in Yorkshire. Again the required plant has a low

profile and there is no significant visual impact on the environment. There is no suitable aquifer in this country being used for gas storage at the moment.

The last main form of strategic storage is liquefied gas (LNG). It has the advantage that it can be sited where it is most needed. LNG storage, in tanks about 45m high, presents more amenity problems than the other methods and the local authorities and population must also be satisfied that adequate safety features are incorporated into the site. The visual aspects are dealt with according to the location. A large storage of LNG at a port may be treated purely as a petrochemical plant, but when natural gas is liquefied into a few tanks isolated in the countryuside it is necessary to reduce any visual impact or make it more acceptable. In one situation this may mean blending the colours to those of the sky whilst in another it may mean giving the impression that the tanks are part of the background when viewed from a distance.

2.5 Reducing Local Nuisance

All the above environmental care could be cancelled out, however, if the lower pressure distribution system for the gas in urban areas had a significance leakage. That would then entail large numbers of excavations, irritation to the public and, incindentally, could lead to vegetation damage by displacement of oxygen in the soil. Where the changeover from towns' gas to natural gas was likely to lead to drying out of jointing materials, such as jute or rubber, considerable effort was made before the changeover to develop effective methods for leakage control. Research is continuing on leakage control to eliminate losses and to minimise the disturbance to traffic whilst at the same time reducing noise nuisance to the public. Natural gas is a valuable product and every effort is made to minimise potential leakage, both for economic and safety reasons. These efforts include replacement of old pipe systems with new joint free pipe as well as modern leakage control techniques such as direct insertion, lining, encapsulation, anaerobic sealants, internal sealing and more adaptable clamps.

3. NATIONAL TRENDS IN AIR QUALITY

3.1 Smoke Emissions

It was the London 'smogs' of the 1950's that highlighted the need for some control of combustion emissions in the UK, and the subsequent legislation [5] was aimed at the reduction of smoke emissions. Smoke in this context is, of course, suspended particulates less than 15um in size, and it is estimated that coal accounted for 70% of smoke emissions in the late 1970s.

The success achieved in reducing this form of pollution is illustrated by the Department of the Environment (DoE) information [6] plotted in Figure 1. It shows that emissions of smoke have fallen substantially. Indeed the 1985 levels were less than 15% of those recorded in 1960. That was partly due to the implementation of the Clean Air Acts which ensured that consumers in smoke control areas burnt coal efficiently or else switched to other fuels such as gas, solid smokeless fuels, or electricity. An additional factor was that many consumers in areas that were not covered by Smoke Control Orders had switched to cleaner, more convenient fuels. Figure 1 also shows that the average urgan concentrations of smoke closely followed the change found in national smoke emissions.

3.2 Sulphur Dioxide Emissions

The same sort of improvement was also reflected in sulphur dioxide (SO_2) emissions and urban SO_2 levels. It is well known that in the case of fuel combustion within the UK there has been no direct emission control of SO_2 or nitrogen oxides (NO_x) and, for the period discussed here, the best practicable means for controlling gaseous pollution from any combustion processes associated with a scheduled process, such as a power station, a refinery or a gasworks, was to design the height of emission so that it was adequate to ensure good dispersal. The chimney heights were calculated to give a situation that would result in an acceptable ground level concentration of SO_2. If that condition was fulfilled then the concentrations of any other pollutants from

cumbustion processes were considered to be adequately reduced. (For very low sulphur fuels such as natural gas, there are separate methods of calculating the chimney height which take into account other pollutants such as NO_x.)

National emissions of SO_2 in the UK have shown a significant reduction although, as explained above, that was not, in the main, a direct result of national legislation. Several factors have contributed, such as lower demand for electricity for industrial purposes, energy conservation and changes in fuel use. Figure 2 shows how the SO_2 levels have changed with total energy use and increased gas use.

Over the period from 1965 to 1984 the total energy consumption by end user remained fairly steady at about $4.8.10^9$ GJ per year before a decrease down to $4.2.10^9$ GJ per year [7]. Over the same period the towns' gas, and then increasingly the natural gas, share of the market expanded from less than 4.10^8 GJ per year to more than $1.8.10^9$ GJ per year. Total emissions of SO_2[8] also shown in Figure 2, remained relatively stable in the 1960s at about 6.10^6 tonnes per year but decreased to 5.10^6 tonnes by 1976 and then to less than 4.10^6 tonnes by 1983. Over the same period the average urban concentration of SO^2 fell from over 100ug m^{-3} to just above 40ug m^{-3}. Natural gas contributed significantly to this decrease because it is virtually sulphur free in terms of pollution potential.

Coal in the calender years 1984 and 1985 gave rise to emissions of $1.93.10^6$ and $2.53.10^6$ tonnes of SO_2 respectively out of annual totals of 3.54 and $3.58.10^6$ tonnes [6]. Overall, power stations were responsible for 70% of the SO^2 emissions in 1984 and 1985.

The long term trend illustrated in Figure 2 emphasises the significant reduction that was achieved in the emissions of SO^2 from combustion, not by direct legislation, but through changes in fuel use. Indeed, the total natural gas available in 1982/83 and 1983/84, while accounting for about 32% of the heat supplied, only gave rise to total SO^2 emissions of 750 and 792 tonnes in those two years, i.e. less than 0.02%.

This contribution towards lower SO^2 emissions is also seen in

other countries e.g. in Italy the use of 33 billion m^3 of natural gas instead of other fuels in 1985 is calculated [9] to have been equivalent to an annual reduction of 1.1 million tonnes of SO^2 and in the Federal Republic of Germany (FRG) the use of natural gas is equivalent to an annual reduction of 0.8 million tonnes of SO^2 or 25% of the SO^2 [10]. In countries such as the Netherlands and Ireland a significant fraction of the fossil fuel power plant uses gas and similar positive effects must accrue.

3.3 Nitrogen Oxides Emissions

In contrast to SO^2 emissions those of NO_x have not shown a decrease in recent years. The production and emission of NO_x are functions of combustion conditions and are much more difficult to quantify. The best estimates by the DoE show a recent increase [6]. However, even for the level of these emissions the use of natural gas will have an overal beneficial effect because, unlike coal and liquid fuel, it does not have, within the fuel itself, nitrogen compounds that would contribute to the total NO_x emission form fuel combustion.

Data published by the DoE showed estimates of NO_x emissions in the UK (expressed as NO_2 of 1634.10^3 tonnes in 1982 and 1856.10^3 in 1983. An estimate of the NO_x arising from gas use was calculated using emission factors for gas published by OECD [11]. The total emission was just over 80.10^3 tonnes or less than 5% of the reported estimated total for the UK NO_x emission. The main contributors are shown in Figure 3. More recent estimates of emission factors are somewhat higher from specific plant and calculations have been repeated using EPA data 12 and Dutch emission factors [13]. Those calculations suggested that percentage could be 5-7% of the quoted national total. For 1983 the percentage would be somewhat less. Thus, natural gas, a fuel that accounts for 32% of the heat supplied (or 23% of the primary energy, is estimated to yield only approximately 6% of the total UK NO_x emission.

3.4 Hydrocarbon Emissions

Another factor that is involved in the present air quality and

acid deposition debate is gaseous hydrocarbon emissions, and their interaction with other airborne species. Those emissions need to be considered because one of the most important atmospheric reactions in air pollution chemistry is that between the hydroxyl radical and hydrocarbons.

TABLE 1 - Reactivity of hydrocarbons with the hydroxyl radical

	Reactivity (compared with methane	Abundance (% by weight) in Sydney	Contribution to total reactivity of air (%)
Vehicle	248	36)	33)
Petrol	279	16)68	17)76
Petrol vapour	426	16)	25)
Gas mains leaks	63	4	1
Process propylene	1250	1.8	8.4
Solvents	162	23	14

The relative reactivities of the hydroxyl radical with different hydrocarbons vary widely [14] and show that methane is relatively unreactive. The data in Table 1 came from a study in Sydney, Australia [15]. Any estimate of the contribution that estimated gas leakage might make to reactive hydrocarbons will need to take into account the fact that natural gas is mostly methane. It seems therefore more appropriate to consider not the total natural gas leakage figure, but the non-methane hydrocarbons from gas released into the atmosphere. A rough estimate shows that one tenth of the weight of natural gas is non-methane hydrocarbons. At this time the best estimate of leakage that can be made by British Gas is about 1%, or for non-methane hydrocarbons in 1982, 0.1% of throughput or about 32.10^3 tonnes. When that value has been substituted into the 1982 DoE figures and converted to a percentage it amounts to 2.5% of the estimated national emission of non-methane hydrocarbons. Figure 4 shows the same percentage for 1986. It is worth noting that emissions of biogenic methane are substantial and estimated worldwide at about 2×10^8 to 10^9 tonnes per year. Methane from natural gas leakage is clearly a minor source when compared to natural emissions.

A recent Harwell report [16] on photochemical pollution, in particular ozone formation, describes modelling studies downwind of London during a day. The report considered natural gas leakage to have little impact on the secondary pollutants within the timescale studied.

The EC is currently considering the subject of hydrocarbons emissions, and progress has recently been made in agreeing controls on hydrocarbons emissions from motor vehicles. Solvent evaporation, the other major contributor, will also need to be controlled and individual countries such as France are already working on programmes. The National Society for Clean Air is, of course, well informed on the topic of hydrocarbons emissions and is actively considering it at the moment.

3.5 Greenhouse gases

A paper to Conference last year by Jenkins [17] referred to the 'greenhouse effect' and global warming. The main substances responsible for this effect are carbon dioxide (CO_2), produced by the burning of all fossil fuels, and water vapour. Other contributors are ozone, methane, chlorofluorocarbons, nitrous oxide and other trace gases.

There is evidence that global CO_2 levels are increasing and some evidence that the temperature of the atmosphere is rising; the most commonly reported estimates are that a doubling of the CO_2 concentrations from the present value of 0.03% would raise the temperature by $3^oC + 1.5^oC$ by the year 2070. The interaction of CO_2 with the ocean mass and the effect of other trace gases are two of the factors that may affect the timing.

Methane from any source contributes to the greenhouse effect but as we have already shown, that arising from the leakage of natural gas supply is a small fraction of the emissions from biogenic sources. As we have noted earlier there is continued effort to minimise such leakage.

As with the acid deposition debate there are scientists who take a very pessimistic view and wish to see immediate action taken to curb the use of fossil fuels: there are others

who remain to be convinced that nature does not have the capacity to adjust and balance the effect of increasing concentrations of CO_2 or other gases. The latter group believe that research should continue into the greenhouse effect, and renewable sources of energy, but it does not support at present any drastic measures to curb the use of fossil fuel. Of all the fossil fuels natural gas produces the least CO_2 per unit of energy supplied because of its high H/C ratio. However, this is an important long term issue that requires monitoring as the debate develops, although it is difficult to see a fully practical solution, at present, that will satisfy everyone.

4. FUTURE GAS SUPPLIES

4.1 Natural Gas

The benefits from the use of natural gas are a long term asset. Proven world-wide reserves are sufficient for the next 50 to 60 years [18] and additional recoverable reserves will probably provide us with gas for the next hundred years [1]. This may involve long range transportation of gas but there are already existing major pipelines, and sea transport of LNG is a proven environmentally safe method. This flexibility of supply means that gas could be supplied to Europe from virtually anywhere in the world if necessary.

4.2 Coal Gasification

Coal is a form of energy of which there are vast resources. Gasification is an environmentally attractive route for converting it to a form of energy that can be used in a variey of ways without generating sulphur dioxide and can thus maintain or increase the benefits in air quality already gained through the use of natural gas.

A number of processes for gasifying coal have been and are continuing to be developed with different objectives. The British Gas/Lurgi Slagging Gasifier was designed to efficiently gasify bituminous coals.

The gas can be readily purified and has special advantages as a starting material for processing to produce substitute

natural gas (SNG). The two main waste products of gasification are a solid glassy frit and a liquid effluent. The frit has been shown through leaching tests to present no environmental hazards and would be suitable for landfill disposal. The liquid effluent can be treated in a number of different ways to ensure environmental acceptability [19].

One of the earliest potential applications for gasification technology is for power generation using combined cycle systems with at least 90% reduction in sulphur oxides emissions. Interst has been expressed both abroad and in this country, indeed it is one of the technologies that has been considered in a joint study by CEGB, British Gas and British Coal under the auspices of the Department of Energy.

Another application of gas/coal technology is the use of natural gas to help reduce the emission of pollutants from other fossil fuels. This is of particular interest in the USA where gas/coal co-firing, gas reburn and gas enhanced dry sorbent are being studied [20].

4.3 Conservation

All energy is expensive, and wasteful use is no longer acceptable to society. Considerable research is directed towards the more efficient use of gas and one result has been the reduction of emissions by increasing conservation, and this has been achieved at the same time as markets have been expanded [21,22].

The "GEM" (Gas Energy Management) Awards were started by British Gas in 1975 and are a means to promote efficiency in industrial and commercial consumers. During 1983 43 million therms were saved and in individual cases fuel savings of 36% for process heating and 23% for space heating were achieved.

Industrial burners operating at high levels of combustion air preheat can achieve 50% energy savings. In these high-temperature processes higher levels of nitrogen oxides are produced but compared with the alternatives using other fuels, because of the absence of sulphur dioxide and ash, these devices make an overall positive contribution to air

quality.

5. DEVELOPMENTS IN LEGISLATION

5.1 Present UK Legislation

In the case of fuel combustion there are, as yet, in the UK, no emission controls on sulphur dioxide (SO_2) and nitrogen oxides (NO_x from combustion processes, although that is likely to change as a result of developing best practicable means and EC pressures to control emissions. Indeed there are already EC Directives covering ambient air quality [23,24].

Air pollution control in the UK is still firmly rooted in the long-standing concept of best practicable means (bpm). The concept of best practicable environmental option (bpeo) which takes into account the potential pollution of air, water and land is gaining wide interest. It is under study by the Royal Commission on Environmental Pollution, by Her Majesty's Inspectorate of Pollution and has been the subject of a report by the United Kingdom Environmental Law Association [25]. The use of natural gas as a fuel could be considered as the bpeo for many applications.

UK air pollution legislation is currently under review and as a result of that local authorities are likely to have wider powers. At present the approach to emissions control in the UK is still essentially pragmatic with each source considered on a case by case basis. But the increasing pressure to control not only SO_2, but NO_x and hydrocarbons as well, could lead to European proposals for fixed limit values in the future.

5.2 Further Legislation on Emissions

Natural gas already provides significant environmental benefits towards improved air quality and within the gas industry the question arises "How much further should the industry be asked to go?" That question is not fully resolved yet and perhaps it is one that will be discussed in a coordinated way in order to reach a consensus. There are several aspects of the question. There is the limit in plant size below which the economics of control may be very

unfavourable; there is the difference in approach required for existing and new plant; the timescale is important; high temperature and high efficiency plant need special consideration; and there is the need for economic justification so that any additional expenditure on emission control, and its maintenance, is seen to result in the same order of environmental benefit as other measures such as NO_X reduction from vehicles.

Individual EC Members are permitted to introduce more severe emission limits than those agreed by the Community as a whole or even where none exist already. The EC draft Large Combustion Plant Directive has shown that considerable time and effort may be wasted if the initial proposals are too far removed from the consensus of what is practical, technically or economically. Some try to argue that natural gas, a fuel with low emissions, would become even more attractive from a marketing point of view if stringent limits were placed on emissions from its use.

It is not possible to give a detailed picture of emission controls here but there are some remarks on general trends worth noting. As far as the EC is concerned only the draft Large Combustion Plant Directive has come forward with specific proposals for emission limits from the combustion of fossil fuel (if transport is excluded). A few Member countries already have, or will have, similar limits in force to those proposed. The Federal Republic of Germany (FRG) limits apply to plants rated at 10 MW and above; those of the Netherlands apply to ratings of 2.5 MW and above; and in one European country, outside the EC, plants down to 1 MW in rating are considered for such control.

It is obvious from the data in Table 2 that the type of limits being proposed and implemented in the FRG are much more severe for gaseous fuel than for the others [26].

Natural gas has already been used to provide rapid and measurable improvement of urban air quality and further improvements could be made in some areas. To demand too much in the way of decreased levels of NO_X may affect specific markets. Any resultant switch to other fuels with higher sulphur or bound nitrogen contents would increase the

overall emissions.

TABLE 2 - Emission limits for NO_X for new installations in the Federal Republic of Germany

	10 - 50 MW		100 - 300 MW	
Fuel	mg m^{-3}	$g.GJ^{-1}$	mg m^{-3}	$g.GJ^{-1}$
Gas	200	56	200	56
DIN 1603 Oil	250	72	-	-
Other Oil	450	134	-	-
Fuel Oil	-	-	300	91
Coal	642	190	-	-
Coal (a)	385	114	-	-
Hard Coal (b)	-	-	514	152
Hard Coal (c)	-	-	480	142

All values calculated at 3% oxygen.
Data from reference (26)
(a) Stationery Fluidised beds with heat output >20 MW: fluidised bed installation with circulating fluidised bed.
(b) Grate firing
(c) Dry firing

The wide range of emission factors, between different plants of the same type and between each class of plant, makes it essential to have considerable discussion before legislative proposals are put forward. Burner systems designed to give increased fuel efficiency should have some special consideration so that the required limit can be modified by the introduction of an efficiency ratio. That approach has already been considered by some EC member countries in the equation used to calculate emission limits for gas turbines in the FRG [26] and in the [27]. Allowances are made, in the emission limits of some other plant, as the preheat temperatures varies [26], and so more efficient use of fuel is encouraged.

Most countries will wish to keep a balance of fuel use. Gas, in competition with other fuels, including electricity, may be under pressure to accept increased control on emissions especially if more emphasis is placed on NO_X reduction in

power plant [28]. The case for new emission limits should be convincing, the technology proven and realistic costings made available.

6. CONCLUSIONS

Natural gas is a clean fuel which can be supplied to the customer without significant adverse effects on the environment. Its use over the past few decades has made a substantial contribution to improvement of air quality nationally and especially in the urban environment.

It is essentially sulphur and particulate free and produces less NO_x per unit energy than most fossil fuels. However, the emission standards proposed for natural gas are always stricter than for the other fuels. It is important that these standards are carefully considered, so that they do not discourage the use of natural gas, an environmentally advantageous fuel. The use of variable emission factors, which would take into account any higher efficiencies achieved, and the economic of implementing the required control technologies need to be taken into account.

7. REFERENCES

1. Cometec-Gaz 1987 EYE "Gas and the Environment".

2. Baubeau, P.L. et al. 27--31 October 1986, Symposium on the Gas Industry and the Environment, Stuttgart. "Onshore and offshore exploration, production and underground storage of gas".

3. Schlem, F. and Sandkuhler, H. 27-31 October 1986, U.N.E.C.E. Symposium on the Gas Industry and the Environment, Stuttgart. "Technical requirements on sourgas production and purification systems due to environmental regulations in the Federal Republic of Germany".

4. Delivre, F. et al. 27-31 October 1986, U.N.E.C.E. Symposium on the Gas Industry and the Environment, Stuttgart", "Integration of underground storage surface installtion in the natural environment".

5. Clean Air Acts 1956 and 1968, Her Majesty's Stationery Office, London.

6. Department of the Environment, 1987 Digest of Environmental Protection and Water Statistics, No. 9, 1986", Her Majesty's Stationery Office, London, 1987.

7. Department of Energy, 1985 "Digest of United Kingdom energy statistics", Her Majesty's Stationery Office, London.

8. Department of the Environment, 1985. "Digest of environmental protection and water statistics, No. 7, 1984". Her Majesty's Stationery Office, London.

9. Colapaoli, E. 27-31 October 1986. U.N.E.C.E. Symposium on the Gas Industry and the Environment, Stuttgart. "The role of natural gas in reducing emissions from large combustion plants".

10. Haeberlin A. 27-31 October 1986, U.N.E.C.E Symposium on the Gas Industry and the Environment, Stuttgart. "The role of natural gas in reducing emissions from large combustion plants".

11. OECD Study, ENV/EN77. 10 August, 1977.

12. Compilation of Air Pollutant Emission Factors, 3rd Ed., Environmental Protection Agency, Research Triangle Park, N.C., April, 1981.

13. Handbook of Emission Factors, Volume 2, Industrial Sources, Ministry of Housing; Physical Planning and Environmental, M.E. Reinders, Government Publication Office, The Hague, 1984.

14. Hov. O, September 1986, "Models for photochemical processes", from Regional and long-range transport of air pollution, CEC, Joint Research Centre, Ispra, Italy.

15. Air Pollution. Technology and the Environment No. 12. Part 4, p15, Department of Trade and Industry, 1982.

16. Derwent R.G. and Hough A.M. December 1986 UKAEA Harwell "Ozone precursor relationships in the United Kingdom".

17. Jenkins G.J. 1986, NSCA Annual Conference "Global effects of trace gas changes".

18. Roberts G.F.I. June 1987 IIRS Industrial Utilisation of Natural Gas. "Natural gas - a world wide review".

19. Shephard, F.E. and Watkins, D.M. October 1986, UNECE. Symposium on the Gas Industry and the Environment, Stuttgart "Some environmental aspects of coal gasification".

20. Wiersma S.J. et al. November 1986, "The use of natural gas for pollution control", Gas Warme Int. 35 (9), pp479-484.

21. Jones, R.J. Personal Communication.

22. Knapp, U. 27-31 October 1986, U.N.E.C.E. Symposium on the Gas Industry and the Environment", Stuttgart. "The endeavours of the Gas Industry of the Federal Republic of Germany for the economical use of energy and the effect on the environment.

23. EEC Directive on Air Quality Limit Values and Guide Values of Sulphur Dioxide and Suspended Particulates, 80/779/EEC, OJ L229, August 1980.

24. EEC Directive on Air Quality Standards for Nitrogen Dioxide, 85/203/EEC, OJ L87/1, 1985.

25. United Kingdom Environmental Law Association, 1987 "Best Practicable Environmental Option - New Jerusalem?" Editor Stephen Tromans.

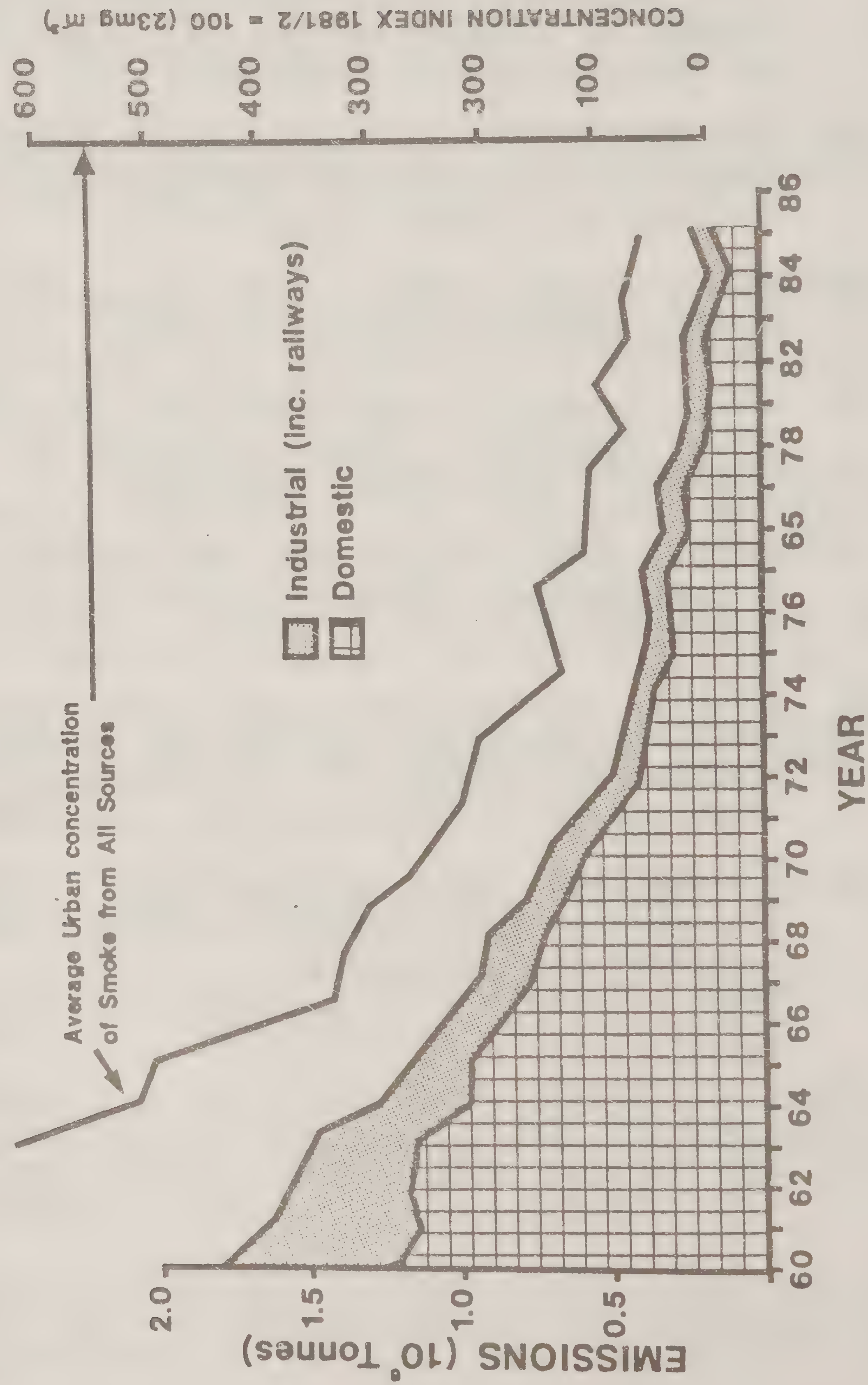
26. Kolar J. 1986. NO_x emission and reduction measures - an international comparison", Gas Warme Int., 35(4) pp227-238.

27. Overdiep, J.J. and Broer, W.T. 27-31 October 1986, U.N.E.C.E. Symposium on the Gas Industry and the Environment, Stuttgart. "Environmental regulation issues and gas transmission in the Netherlands".

28. Environmental Data Services Ltd. April 1987. "Government, CEGB set to move on power station emissions" ENDS. 147 pp4-5.

FIGURE 1

CHANGES IN SMOKE EMISSIONS AND AVERAGE URBAN CONCENTRATIONS OF SMOKE IN THE UK



21. Jones, R.J. Personal Communication.

22. Knapp, U. 27-31 October 1986, U.N.E.C.E. Symposium on the Gas Industry and the Environment", Stuttgart. "The endeavours of the Gas Industry of the Federal Republic of Germany for the economical use of energy and the effect on the environment.

23. EEC Directive on Air Quality Limit Values and Guide Values of Sulphur Dioxide and Suspended Particulates, 80/779/EEC, OJ L229, August 1980.

24. EEC Directive on Air Quality Standards for Nitrogen Dioxide, 85/203/EEC, OJ L87/1, 1985.

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26. Kolar J. 1986. NO_x emission and reduction measures - an international comparison", Gas Warme Int., 35(4) pp227-238.

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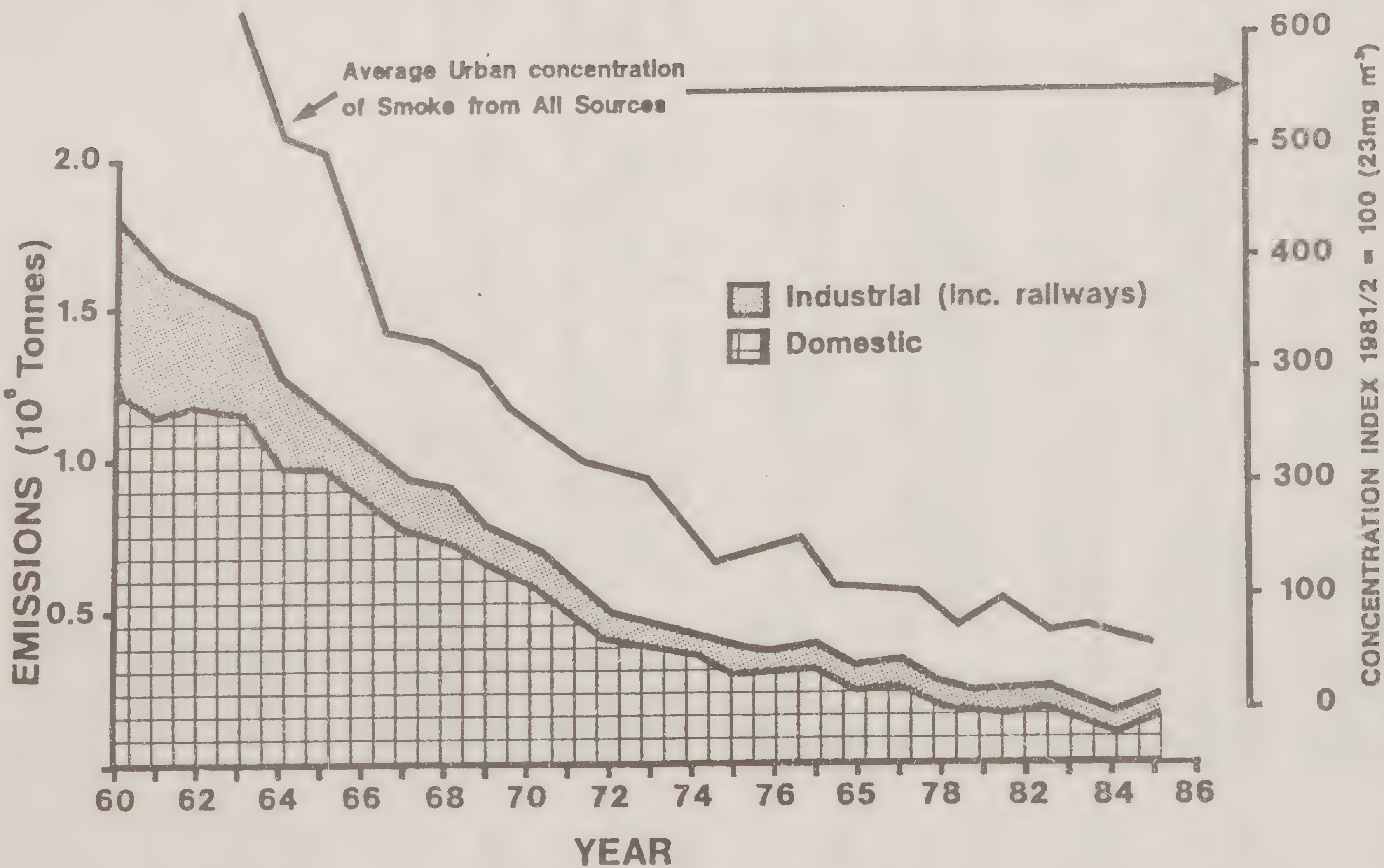
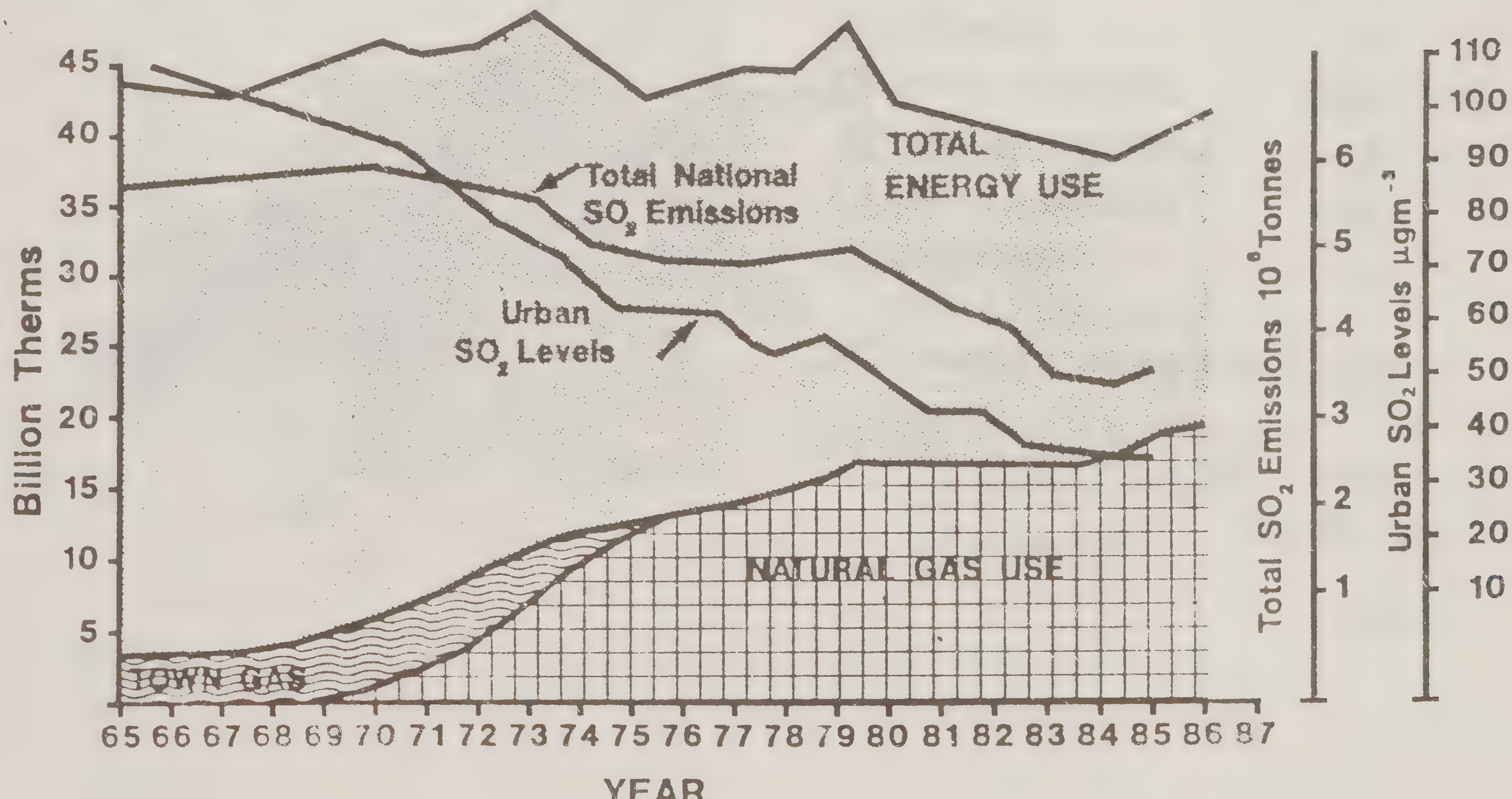


FIGURE 2

TOTAL ENERGY CONSUMPTION BY END USER (LESS TRANSPORT AND FARMS), GAS CONSUMPTION AND SULPHUR DIOXIDE EMISSIONS AND URBAN LEVELS



Reproduced from Reference 6

FIGURE 3

NITROGEN OXIDES EMISSIONS: MAIN SOURCES AND CONTRIBUTION FROM NATURAL GAS 1986

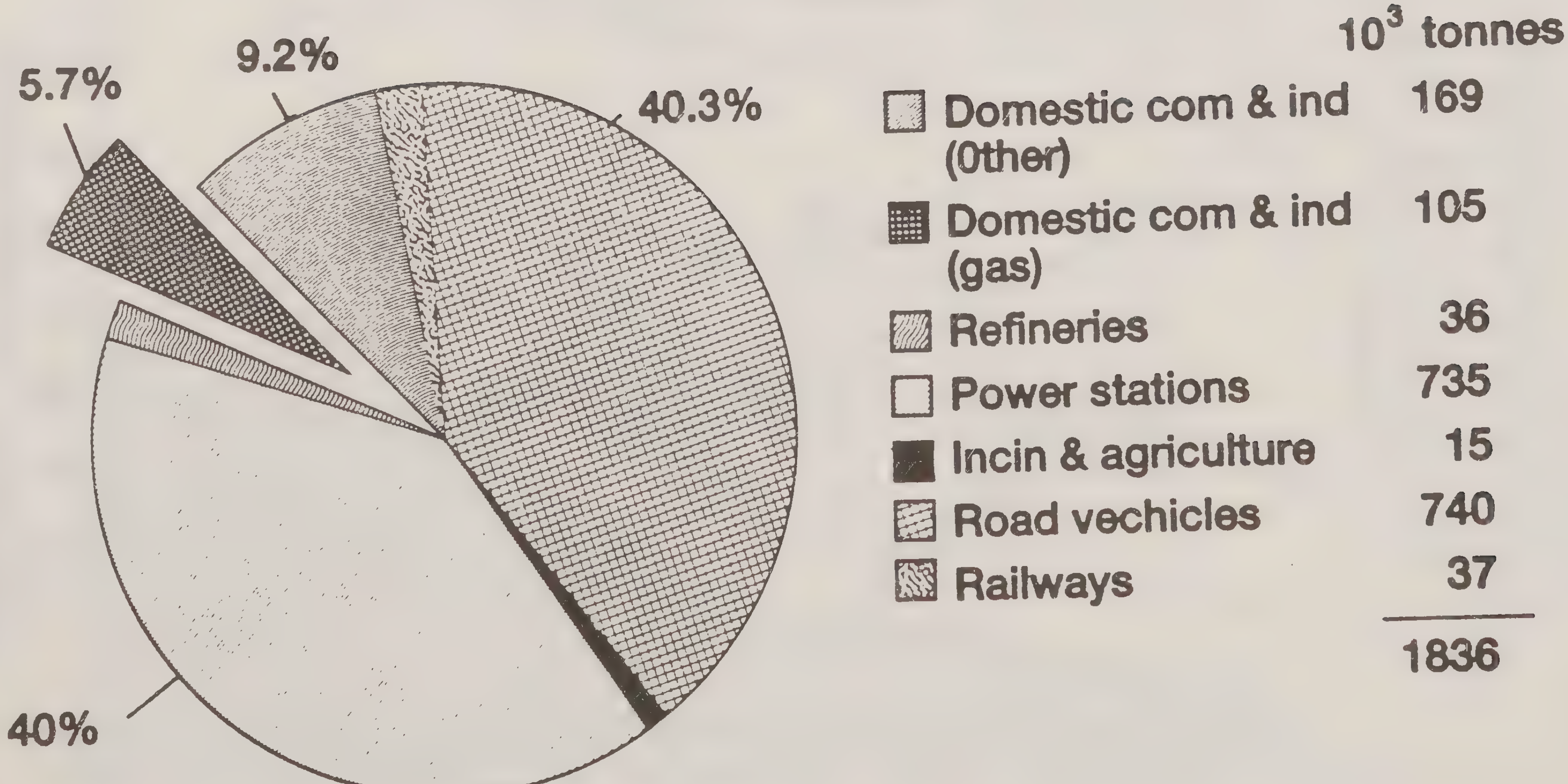
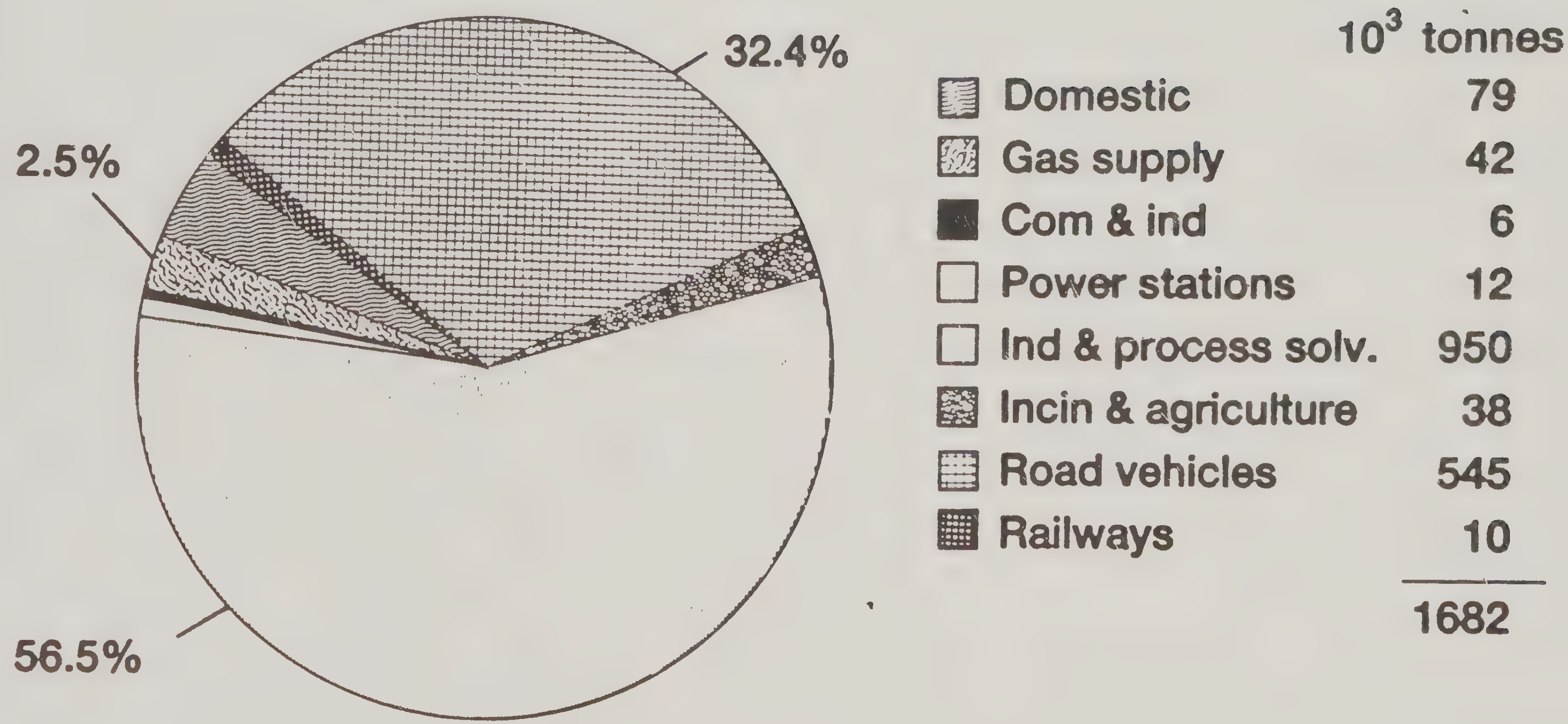


FIGURE 4

ESTIMATED NON-METHANE HYDROCARBON EMISSIONS 1986



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POLLUTION CONTROL IN THE CEMENT INDUSTRY

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1. INTRODUCTION

Portland Cement is a mixture of chemical compounds. The required chemical components are derived (together, inevitably, with some minor impurities) from natural sources:

of lime - combined in the form of carbonate as chalk or limestone (calcareous component);

of silica, alumina and iron oxide combined in the form of clay or shale (argillaceous component).

Both of these components frequently contain quartz (sand) which provides additional silica, although sometimes it is necessary to 'import' sand or iron oxide to obtain the optimum composition.

The materials and processing steps are summarised in the flow chart for a typical dry process works. The raw materials are quarried, crushed and ground to a fine powder in the required chemical proportions. They are then dried and heated to about (1450 °C) in a coal fired kiln system shown in Figure 1. As the material temperature rises, the components decompose with the evolution of water and carbon dioxide (110 - 950 °C). At temperatures above about (1350 °C) partial melting occurs.

Melting accelerates chemical reactions and the clinker formed contains tricalcium silicate, dicalcium silicate, tricalcium aluminate and tetracalcium aluminoferrite in the approximate proportions; 60:20:10:10. The clinker is finely ground with about 5% of its weight of gypsum which acts as a set regulator in the resulting Portland Cement.

A modern one kiln cement plant typically produces 800,000 tonnes of cement per annum requiring some 1m tonnes of limestone and 200,000 tonnes of shale, depending on purity. In addition anything from 95,000 to 175,000 tonnes of coal would be consumed (depending on the raw materials and process employed) and 50,000 tonnes of gypsum. Inevitably

the overall environmental impact of an industry involved in quarrying, grinding, transporting, heat treating and despatching materials on this scale is considerable. It is therefore appropriate, before considering particular aspects of pollution control, to summarise briefly the wider environmental regulatory framework within which the industry operates.

1.1 PLANNING & REGULATORY REQUIREMENTS

Building a new cement works, or significantly modifying an existing one is, like most other forms of development, subject to the requirements of the Town & Country Planning Act 1971. Conditions attached to a planning consent may seek to minimise the visual impact of the plant and will probably include a planned development and reclamation programme for the quarries. Requirements are usually more onerous in National Parks or Areas of Outstanding Natural Beauty.

The European Council Directive on the assessment of the effects of certain public and private projects on the environment (85/337/EEC) puts installations for the manufacture of cement in Annex II. This lists industries for which the requirement of environmental impact assessment is left to Member States. However, in the UK the present planning process enables a full study of the environmental implications of a development to be undertaken as considered necessary - particularly in respect of major projects.

The major potential pollutant in the industry is dust and plant for the manufacture of cement clinker and/or the grinding of it must be registered under the Alkali etc Works Regulation Act (1906). Best Practicable Means Notes are issued for the guidance of works' management by the Inspectorate of Pollution which monitors performance, currently under the Health and Safety at Work Act (1974). Sites involving only bag packing plant and storage were de-registered under the Health and Safety (Emissions into the Atmosphere) Regulations 1983. They are included in Part B of the two part schedule proposed by the DOE (December 1986) and would be monitored, and new sites given prior approval, by local authorities.

Noise is increasingly becoming part of all new planning consent requirements, and local authorities are requiring that boundary noise levels are stringently controlled to avoid complaints in the community.

Any development, but especially quarrying operations, may also be affected by the requirements of the Wildlife & Countryside Act (1981) which defines protected flora and fauna and procedures relating to closing or diverting public rights of way.

In cement manufacture liquid effluent problems are few: process water, surface drainage, lorry wash effluent and laboratory waste require consents which are provided and monitored by the Regional Water Authority under the Control of Pollution Act.

Solid wastes, where significant quantities arise (eg waste kiln dust at some plants), are used as landfill subject to the requirements of Water and Waste Disposal Authorities, under the Control of Pollution Act.

2. MAJOR SOURCES OF POLLUTION

2.1 DUST

Sources of dust may be classified as one of three types:

a) fugitive emissions arising, for example, from quarrying, roadways and unprotected stockpiles in periods of prolonged dry weather;

b) air cleaning emissions arising wherever the venting of air in contact with dusty materials is necessary - for example at conveyor transfer points or where air is displaced in silo filling;

c) process emissions arising from the exhausting of gases directly involved in the manufacturing process - from the kiln, the clinker cooler and cement mills.

The current notes on best practicable means for cement production (BPM 14) were published in 1982. They outline a code of practice for unquantifiable sources of dust and specify presumptive limits for controlled emissions from new or significantly modified plant as follows:

kiln exhaust (main stack)	100 mg/Sm^3
cooler exhaust, cement mills and air cleaning points	150 mg/Sm^3

In the UK the standard cubic metre (Sm^3) is defined as the volume measured at a temperature of 15 $^{\circ}C$ and a pressure of 1 bar with no correction for moisture content.

In the absence of significant problems or complaints, the presumptive limits for works constructed before 1982 remain at the level originally set, until the opportunity arises to renew or upgrade the dust arrestment plant or make significant process changes.

2.1.1 METHODS OF DUST ARRESTMENT

Fugitive emissions are usually adequately controlled either by wet suppression or by mobile vacuum plant, in the cleaning of roadways for example. In general ventilation air is cleaned by fabric filters and a modern dry process plant may have more than a hundred such units. With adequate design and maintenance emissions well below the presumptive limit can be maintained. Where particularly high burdens of solid material are to be collected, pre-collectors in the form of inertial, gravity or cyclone separators are incorporated, with a fabric filter providing the final gas cleaning.

The temperatures and humidities of process emissions are such as to raise more specific problems which influence the choice of dust arrestment equipment. Economic factors also play a part, of course, and the equipment currently considered most effective in the three key manufacturing operations is:

kiln / preheater / raw mill: electrostatic precipitator

clinker cooler: gravel bed filter OR heat exchanger with fabric filter

cement mill: electrostatic precipitator OR fabric filter

The use of fabric filters in the cement industry is influenced by both gas temperature and humidity. They cannot be employed where humidity is a potential problem since this leads to blinding of the fabric. Where gases are too hot to be filtered directly without causing damage to the filter material a cold air bleed can be employed to reduce the temperature.

Polyester is the normal fabric used for cement making operations and it has a useful upper temperature working limit of 150 °C. If a higher operating temperature is required, then "Nomex" is used which extends the working temperature range to about 190 °C.

2.1.2 Kiln - Preheater System

The electrostatic precipitator, although having a very high capital cost, has the ability to handle large volumes of gas with a small pressure drop (1-2 mbar).

For optimum dust collection the temperature (300-400 °C) and humidity of the combustion gases leaving the preheater in the dry process require adjustment. This may be provided by using the gas to dry the incoming raw materials in the milling operation, but when the mill is not in use this is carried out by spraying water into the gas stream before it passes to the precipitator. This operation is carried out in a conditioning tower which operates with a target exit gas temperature of 150 °C. This temperature ensures optimum conditions for precipitator operation.

Those aspects of precipitator construction which have received most attention in the last decade are: increased robustness of discharge electrodes to minimise electrode breakage; increased sectionalisation of electrode systems; improvement of rectified current supply and improvement of rapping systems. Many of the improvements have been applicable to older plant and have been retrofitted. The

modern cement kiln precipitator is designed to operate with a collection efficiency above 99.9%. A major development has been the introduction of continuous dust monitoring using an instrument which employs light extinction to measure dust concentration in the duct taking gas to the main stack.

2.1.3 Clinker Cooler

The possibility of high temperature and low humidity of the exhaust gas from a grate cooler, coupled with the variability in gas volume and dust burden arising from fluctuations in material particle size and flow rates from kiln to cooler, makes the choice of a conventional filter desirable. The gravel bed filter is not temperature sensitive and functions best at low humidity so that it is now often chosen for new plant. However, the development of gas to air heat exchangers preceding fabric filters has provided an attractive alternative.

2.1.4 Cement Milling

Because a large proportion of the energy employed in grinding is converted into heat, large modern cement mills are well ventilated and cooled internally by water sprays. Exhaust gas temperature and humidity are therefore ideally suited to dust removal by electrostatic precipitation. For cement mills operating without water injection fabric filters would now be the first choice.

2.1.5 Summary

The cement making process primarily involves the production and transport of powders so that considerable effort and expenditure on dust control is inevitable. Duda (1985) gave an example of air and process gas volumes vented for dust collection in a 2000 tonne/day plant as follows:

	m^3/min
raw materials crushing	600
clay/shale drying	1,200

raw meal grinding & blending	3,400
rotary kiln, coal drier, clinker cooler	13,300
cement milling	4,700
cement silos & bag packers	2,000
TOTAL	25,200

This total equates to 23.4 kg air and process gas being dedusted per kg of cement, at an operating cost of between 5% and 7% of total operational costs. Capital cost for dust control in a new cement plant has been estimated as 12.5% of the total cost of the plant (Cement Makers' Federation 1985).

2.2 NOISE CONTROL

Sources of noise may be classified as being relevant to one of two categories:

> boundary noise arising from plant activities whose noise crosses the works' boundary and may therefore affect local residents;
>
> employee noise, which is noise that is often localised within the plant concerned, may not extend to the works' boundary, and is of specific concern to employees.

The current boundary noise situation with respect to planning is indicated in the DOE "Planning Circular 10/73". The basic concept proposed is that wherever possible authorities should seek to avoid increases in boundary noise when considering planning consents.

In order to assess whether an increase is likely, the application of BS 4142 is recommended. The Circular

accepts the difficulty of predicting overall plant noise levels from data for individual items of plant and concedes that problems may arise during commissioning that were not envisaged during design.

The noise control measures usually adopted to comply with the boundary noise requirement are associated with larger items of plant such as fans, compressors etc and involve enclosure, silencing, or modifications to the buildings. Blue Circle has had recent experience of the need to carry out additional silencing due to an unpredicted boundary noise increase. The problem resulted from "pure tone" components from two large fans. Two very large purpose designed silencers were needed to restore community levels to their former night time values.

2.3 ACIDIC EMISSIONS

The high temperature combustion process in a cement kiln produces NO_x which is emitted, although the amount produced by the industry constitutes only a small percentage of that produced by electricity generating plant and road transport. High fuel costs have stimulated research into the improvement of combustion control using a microprocessor - a NOx sensor actually providing the signal for controlling the kiln. Development work has shown the potential for significant reduction in NO_x production with parallel fuel savings.

The alkaline nature of the raw material used in cement making means that the process usually retains at least 75-80% of the sulphur entering it - both fuel and raw materials contain sulphur compounds. It has been estimated by the industry's European Liaison Committee (Submission to the European Commission 1984) that the Industry's emission of sulphur dioxide is only about 3% of that emitted in electricity generation.

2.4 ENVIRONMENTAL BENEFITS

Three positive environmental contributions which the industry can make deserve mention. These are the burning of domestic waste as a kiln fuel supplement (W. Wiltshire)

where landfill is not possible; the provision of landfill sites, and the use of biogas as a partial coal replacement when the landfill is completed.

3. CONCLUSION

The performance of currently available equipment for dust arrestment is such that we are on the asymptotic part of the cost benefit curve. Significant problems of dust emission generally only arise when plant malfunctions, and improvement has been obtained at older plant by refurbishing or replacing smaller items of equipment. It has been estimated that the industry has been spending at the rate of some £2.5m per annum on general improvements. (Cement Makers' Federation 1985). Further improvement will come from increased process control and automation. For example, a rotary kiln is subject to fluctuations in the rate of material movement through it and there is growing evidence that microprocessor control can have a stabilising or smoothing effect.

Noise control measures from an employee and a community standpoint also have to be carefully considered for any new plant or plant modifications. Increasingly this means, in the case of community noise, that before and after noise surveys are necessary in order to ensure that the noise control target has been achieved.

REFERENCES

1. Cement Makers' Federation (1985) quoted in Industrial Air Pollution, Health and Safety 1985, p8, HMSO, London 1986

2. W H Duda (1985) Cement Data Book Volume 1 p 572 Bauverlag, Wiesbaden & Berlin.

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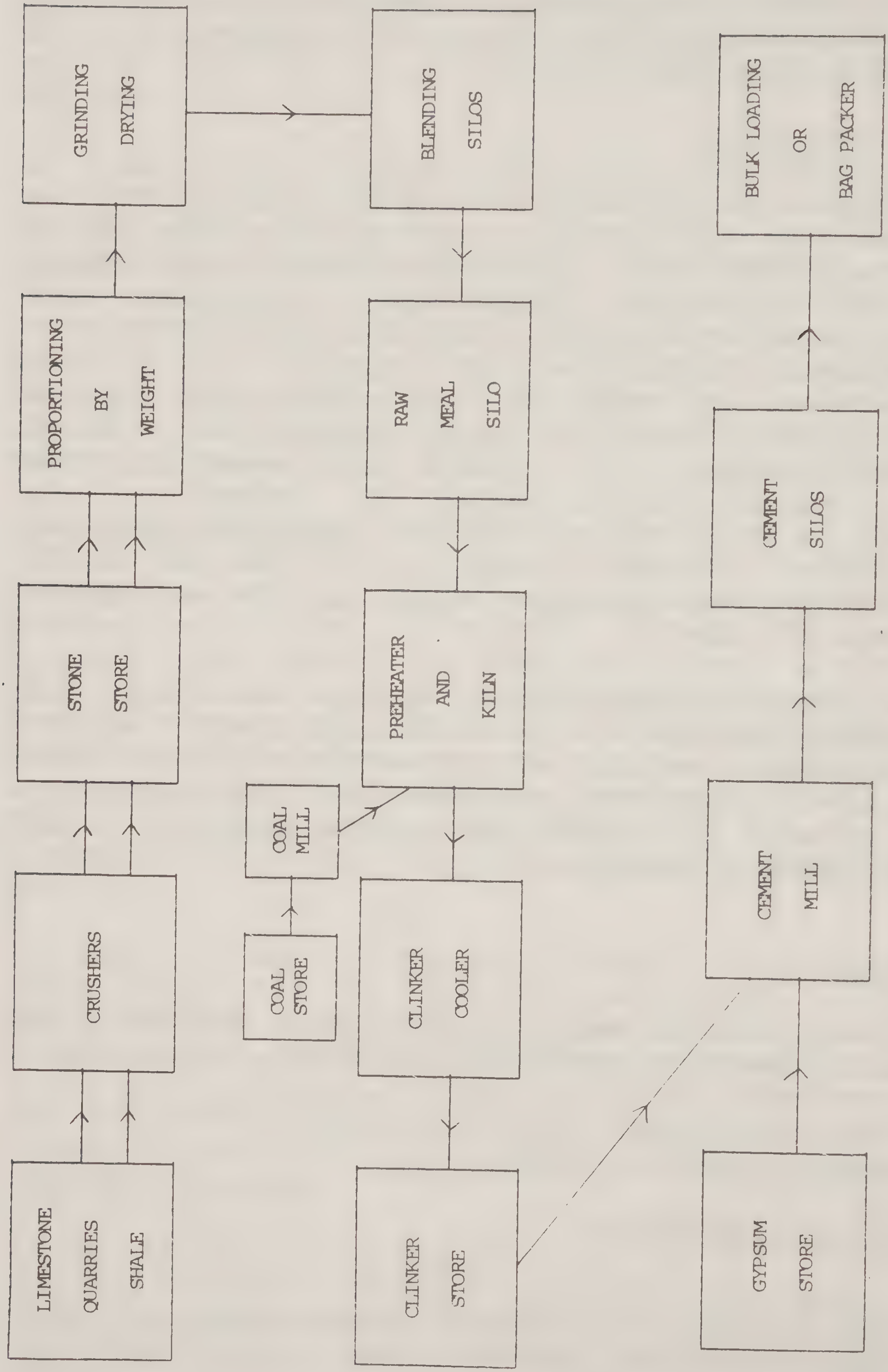
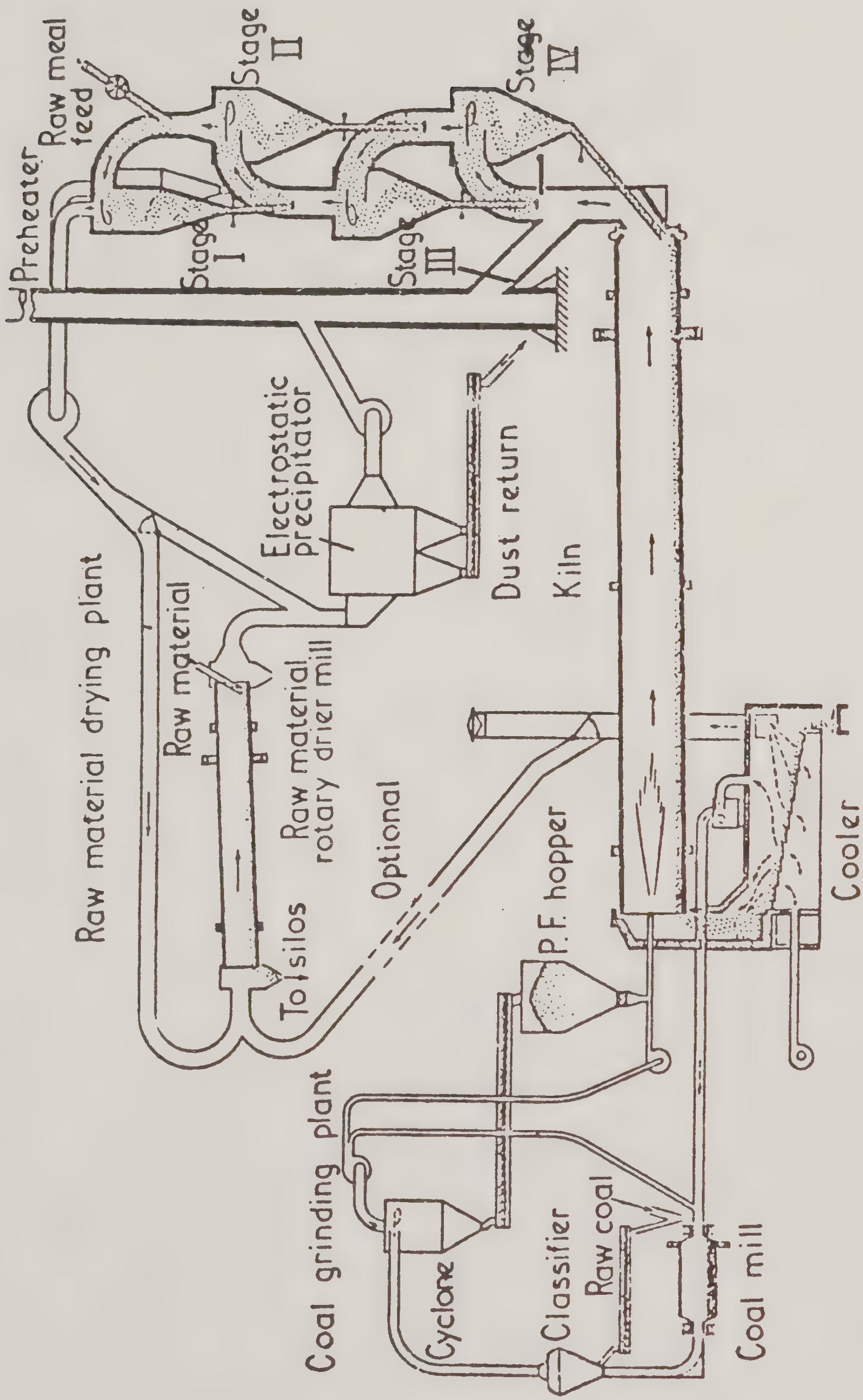


CEMENT MANUFACTURE : DRY PROCESS MATERIALS FLOW CHART

Figure 1

Rotary kiln with suspension preheater and drier



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DOSES FROM ENVIRONMENTAL RADIOACTIVITY

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ABSTRACT

Radionuclides are widespread in our environment. Most occur naturally and are either of primordial origin or are continually produced by natural processes. Radionuclides proced by anthropogenic sources make a small additional contribution to environmental levels but are subject to intensive monitoring programmes and, perhaps inevitably, attract a disproportionate share of public interest.

The aim of this chapter is to discuss the sources of radioactivity in the environment and the routes by which the population is exposed. The scope of measurement programmes within the United Kingdom is briefly described. Finally, doses from the various sources are evaluated and compared.

INTRODUCTION

For some years there has been considerable public concern about radiation in general and man-made radioactivity in particular. Public awareness of the impact of radionuclides in the environment has been heightened even more by the Chernobyl reactor accident. This conference is an opportune occasion at which we can review sources of exposure and discuss potential biological effects of radiation. Many of the following chapters will present doses and risks to particular groups of the public or workers. The aim of this chapter is to provide a review of radioactivity in the environment and to give an appreciation of the doses to which we are all exposed. Thus it may provide a framework within which other exposures can be placed in perspective.

SOURCES OF EXPOSURE

Radiation of natural origin is widespread in the whole environment. Radiation reaches earth from outer space, the earth itself is radioactive and naturally-occurring radionuclides are present in the air we breathe, in the food we eat and in our own bodies. Everyone is exposed to natural radiation and for most people it is the highest contributor to total dose.

Man-made radionuclides have been distributed throughout the world as a result of nuclear weapons testing in the atmosphere. These radionuclides are inhaled, they are deposited on the ground giving rise to external exposure and they can be transferred through food-chains to our diet. Even though the period of intensive weapon testing occurred more than twenty years ago, residual activity from these tests and from occasional more recent explosions still give rise to some small exposure of the population.

Radioactive materials are discharged from nuclear installations, from other industrial premises and from medical and research institutes. All discharges must be authorized and monitoring programmes are prescribed for significant discharges. Operators of nuclear sites monitor the activity before it is discharged and they undertake environmental monitoring programmes. Check measurements, both on discharges and in the environment, are made by the authorizing departments. Organizations, such as medical and research institutions, that discharge small quantities of radionuclides do not normally carry out routine monitoring programmes although in some circumstances the radionuclides they discharge can be readily measured in the environment.

Accidental releases of radionuclides may also occur and, as Chernobyl has shown, a severe accident at a nuclear power station can lead to widespread contamination of the environment.

ROUTES OF EXPOSURE

Radionuclides are subject to all the physical, chemical and biological processes of environmental transfer. No matter how complex the pathway by which the activity may reach man, the actual routes of human exposure are limited to: external irradiation; inhalation of airborne material; ingestion of activity in food or water. Measurements are related to those mechanisms of exposure. Thus, in the environment we measure external dose rates and activity concentrations in air, water and foods. In exceptional circumstances, radionuclides can be measured directly in the human body.

The quantity we cannot measure is the one we require -

dose. Thus, whatever measurements are made, some calculation must be performed to arrive at doses to persons. To put doses from all sources on a common basis, the quantity we require is the sum of effective dose equivalent from external irradiation in a year and the committed effective dose equivalent from intakes of radionuclides during that year. The term committed refers to the dose from intake of a radionuclide integrated over a person's lifetime, taken conventionally to be 70 years. For simplicity, we shall use the term dose, unless clarification is necessary. Even in the simplest case of external irradiation, it is necessary to convert the instrument response to dose in the body and we need to know how long persons spend in the location to calculate the actual dose received from that particular source. In the somewhat more complex situation of intakes of radionuclides, we need to know breathing rates and food consumption rates; we need to know how the radionuclides behave in the body; and we need to calculate the energy absorbed in body tissues over time and from that of the dose.

In the case of most nuclear installations, routine discharges do not lead to measurable dose rates or activities in the environment. Doses must therefore be calculated from a knowledge of the quantities and forms of the radionuclides discharged, their dispersion in the environment and their subsequent fate.

We now consider two sources of public exposure: natural radiation and artificial radionuclides that are widespread in the environment. We shall present average doses for the United Kingdom but, where applicable, we shall also give an indication of the range of doses.

NATURAL RADIATION

The main components of natural radiation are: cosmic radiation; terrestrial gamma-rays; radon decay products; other radionuclides in air, food and water. In recent years, NRPB staff have undertaken an extensive programme of measurements in relation to natural radiation. Here it is possible to draw on only a few results of this work in connection with public exposure.

Outdoor exposure from external irradiation is due almost entirely to cosmic rays and terrestrial gamma-rays. In the United Kingdom, the annual dose from cosmic rays is about 300 μSv, on average.[1] Cosmic radiation varies with altitude and latitude. The annual dose varies from about 280 μSv a year in the south of England to 310 μSv a year in the north of Scotland. Since most of the population lives at low altitude, there is little variation in cosmic ray dose with altitude.

Terrestrial gamma-rays are emitted by radionuclides in the uranium and thorium series and by potassium-40, all of which are present in the earth's crust at concentrations which depend upon the type of rock and soil. We have measured gamma-radiation out of doors throughout Great Britain.[2] The mean value for the country is about 240 μSv a year. However, most people spend most of their time indoors - 75 per cent at home, with a further 15 per cent in other buildings.[3] We have undertaken a study of the national indoor exposure by measurements in some 2000 homes chosen randomly.[4] The measurements were made with two small detectors, a thermoluminescence device for gamma-radiation and a passive detector for the radon-222 concentration. The mean annual dose from gamma-radiation during occupancy of a dwelling is about 380 μSv a year, giving a total annual dose from gamma-radiation of about 400 μSv. The range of values is approximately 200-1000 μSv.

When radon or thoron gas enters the atmosphere from the ground, it is dispersed in the air and concentrations outdoors are low. However, when these gases enter a building, either from the walls or through the floor, the concentrations build up because of the restriction in the supply of outdoor air. The immediate decay products are radionuclides with short half-lives which become attached to dust particles in the air and can be inhaled. Our national survey includes measurements of radon-222 and we have also conducted more detailed surveys in areas where the local geology indicated that elevated exposures might occur.[5] When we include exposure outdoors and in buildings other than dwellings, the average dose from radon and thoron decay products is 800 Sv in a year, but there are considerable variations about

this value.[1] It is worth noting that there are some dwellings in which the occupants are receiving doses of 100 mSv a year, that is, more than the annual dose limit for occupationally exposed workers.

Other radionuclides from the uranium and thorium series are present in air, food and water. Their contribution to average dose is conventionally taken as 170 μSv a year although a value of 90 μSv may be more appropriate for UK diets.[6] The other major contributor to dose is potassium-40 which can be measured directly in the human body. The level of potassium in the body is controlled biologically; it varies with age, sex and state of health. The range of doses for adults of both sexes is probably 110 μSv to 210 μSv with a typical value for a healthy adult male of 180 μSv a year. Other radionuclides in diet make smaller contributions, bringing the total dose from intake to 370 Sv in a year with a probable range of 200 μSv to 400 μSv.

Doses from all natural sources are summarised in Table 1.

ARTIFICIAL RADIONUCLIDES IN THE ENVIRONMENT

The Board operates an environmental radioactivity surveillance scheme to measure concentrations of radionuclides in various media and to evaluate dose to the population from widespread artificial radionuclides. A network of air and rain sampling stations is operated in parallel with the Atomic Energy Research Establishment at Harwell (AERE), but the Board also measures radionuclides in milk as a guide to activity in diet. Until May of this year, the radionuclides detected were generally naturaly-occurring or produced as a result of nuclear weapons testing in the atmosphere. [7]The reactor accident at the Chernobyl nuclear power station in the western Ukraine on 26 April released substantial quantities of radionuclides to the atmosphere, eventually resulting in widespread contamination throughout the whole of the northern hemisphere and leading to substantial increases in measured values.[8]

During 1984, the levels of weapons fallout radionuclides in airborne dust and in deposition were the lowest reported since measurements were commenced in 1953 by AERE.[9]

Similarly, the concentrations of caesium-137 and strontium-90 in milk were the lowest measured.[7] The average dose is shown in Table 2. The dose for external irradiation is estimated from the measured cumulative deposition of activity and models of indoor and outdoor exposure. The dose from carbon-14 is calculated from the excess activity per unit mass of this radionuclide in the biosphere, from reference dietary intake and standard metabolic and dosimetric models. For strontium-90 and caesium-137, the doses are based on measured concentrations in milk with an extrapolation to total diet and again on standard metabolic and dosimetric models. The average dose in 1984 was about 7 μSV, compared with a value of about 80 μSv in the early 1960s.[1] Currently the range of doses within the United Kingdom is perhaps 6 μSv to 10 μSv. Levels and doses for 1985 are similar to those for 1984, and, in the absence of a further input, were expected to continue to decline, but only slowly.

The accident at the Chernobyl reactor will be dealt with in a later session, but no discussion of doses from environmental radioactivity would be complete without at least a brief mention of this. Persons were exposed by several mechanisms: immersion in the cloud; inhalation of acitivity; irradiation by deposited material; ingestion of radionuclides. In the intermediate and longterm, the radionuclides of radiological significance are the caesium isotopes since these are transferred through food chains to our diet. As a result of the accident, the concentration of caesium-137 in airborne dust reached a value of almost 1 Bq m^{-3}, considerably higher than any concentration measured during the period of intensive weapons testing, but, since the activity was injected at low elevation in the troposphere, this level persisted for only a short time in contrast to the stratospheric fallout from weapons tests.

The deposition of activity was dependent upon meteorological conditions at the time of the passage of the contaminated air mass. High deposition occurred in those parts of the United Kingdom where it rained heavily during the passage of the cloud. These include north Wales, the Lake District and south-west Scotland. Deposition is measured either by collecting rainfall or, at later stages, by taking soil cores.

In the 'wet' regions, the deposition of caesium-137 from this accidental release now predominates over the weapons fallout level but, in areas where it did not rain, dry deposition of activity has made a negligible addition to cumulative levels from weapons testing. Concentrations of caesium-137 in milk reached peak values of 40 Bql^{-1} in the United Kingdom as a whole, 200 Bql^{-1} in the wet areas, compared with typical values of 0.06 Bql^{-1} before the accident. Caesium isotopes can be measured in other foodstuffs and the results used to infer dose from diet, but the activity can also be measured in the human body and, in the long term, the *in vivo* measurements will provide a basis for refining dose estimates from contamination of diet with these radionuclides.

Our current estimates of dose in the United Kingdom from all mechanisms of exposure as a result of the Chernobyl reactor accident are given in Table 3. The average value for all years is 50 μSv, but the dose to persons resident in areas of high rainfall may be a factor of five higher. These values are less than the estimates given in a preliminary evaluation of doses in the UK.[10] The difference in the values arises for two main reasons. Firstly, deliberately cautious assumptions were made in the early paper. Secondly, more detailed information that was not available early in May has permitted better delineation of areas of high deposition and these are now known to affect fewer people than originally estimated.

Finally, we consider the dose from discharges from the nuclear industry. The most important pathway is liquid discharges leading to contamination of fish and shell-fish. The dose to the population as a whole is estimated by the Directorate of Fisheries Research from data on fish and shell-fish landings from relevant sea areas and measurement of average concentrations of fission products and actinides in fish and shell-fish in these areas.[11] The collective dose to the UK population in 1984 was 70 man Sv. These doses are not distributed uniformly over the population; they range from zero, for those individuals who do not consume fish and shell-fish, to around 1000 μSv for avid consumers in Cumbria. If we were to average this dose over the whole population, the result would be 1.3 μSv (Table 4). Discharges of other

radionuclides do not lead to measurable concentrations and thus doses are calculated from models of dispersion, depletion and accumulation in water bodies followed by an analysis of ingestion, inhalation and external irradiation.[12] On average, these would add almost 0.1 μSv.

Discharges to atmosphere do not give rise to measurable levels of activity in the environment and, again, we must resort to calculations of dispersion, deposition and subsequent transfer through the terrestrial environment, followed by analysis of inhalation, ingestion and external irradiation.[12] This source of exposure adds a further 0.1 μSv to the average dose.

SUMMARY OF DOSE FROM ALL SOURCES

We can now compare doses from all sources of exposure (Table 5). The use of radiation and radionuclides in medical diagnosis and therapy, although of direct benefit to the patient, makes a significant contribution to the average dose to the population. It is the largest man-made source of exposure. The distribution of medical doses is obviously not uniform; many persons will, for many years, receive no dose at all from this source. The average dose to occupationally-exposed persons is 1400 μSv in a year; averaged over the whole population, this makes a small contribution of 8 μSv a year. Finally, most members of the public receive some exposure from a number of sources such as luminized watches, television receivers and air travel; such miscellaneous sources contribute 11 μSv a year on average.

There is no doubt that natural radiation is the dominant source of exposure and the variations in this contribution are much larger than the total dose from man-made sources. For the current year, the Chernobyl reactor accident is the most important source of dose from artificial environmental radioactivity, but even this is not as high as the dose received from weapons testing in the 1960s. Weapons fallout, the Chernobyl reactor accident and controlled discharges together account for only a few percent of the total dose we all receive. This does not imply that such sources are justified, nor that we can neglect them, but it

does perhaps give a sense of proportion to public exposure as a whole.

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REFERENCES

1. J.S. Hughes and G.C. Roberts, The radiation exposure of the UK population - 1984 review, *NRPB-R173* (1984).
2. E.J. Bradley and B.M.R. Green, Outdoor gamma-ray dose rates in Great Britain - preliminary results. *Radiol. Prot. Bull.*, 59, 16-19 (1984).
3. L. Brown, National radiation survey in the UK: indoor occupancy factors. *Radiat. Prot. Dosim.*, 5, 203-8 (1984).
4. B.M.R. Green, L. Brown, K.D. Cliff, C.M.H. Driscoll, J.C.M. Miles and A.D. Wrixon, Surveys of natural radiation exposure in UK dwellings with passive and active measurement techniques. *Sci. Tot. Env.*, 45, 459-66 (1985).
5. K.D. Cliff, A.D. Wrixon, B.M.R. Green and J.C.H. Miles, Radon and its decay-products: occurrence, properties and health effects, ed. P.K. Hopke. Washington, American Chemical Society, in press.
6. J.L. Smith-Briggs, and E.J. Bradley, Measurement of natural radionuclides in UK diet. *Sci. Tot. Env.*, 35, 431-40 (1984).
7. D.M. Smith, G. McAllister, D. Welham and D. Orr, Environmental Radioactivity Surveillance Programme: results for the UK for 1984. *NRPB-R189* (1985).
8. M.C. O'Riordan, and F.A. Fry, Cloud over Britain: dose from Chernobyl. Presented at the meeting of the British Association for the Advancement of Science, Bristol, 1986.
9. R.S. Cambray, K. Playford and G.N.J. Lewis, Radioactive fallout in air and rain: results to the end of 1984. *AERE R11915* (1985).
10. F.A. Fry, R.H. Clarke, and M.C. O'Riordan, Chernobyl reactor accident: early estimate of radiation doses in the UK. *Nature*, 321, 193-5 (May 1986).

11. G.J. Hunt. Radioactivity in surface and coastal waters of the British Isles 1984. *Aquatic Environment Monitoring Report Number 13*. Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research, 1985.
12. G. Lawson, N. McColl, J.A. Jones, J. Williams, J. Dionian, and J.R. Cooper, The radiological impact of routine discharges during 1970 to 1989 for the UK civil nuclear power programme. To be published.

Table 1 Annual dose in the UK from radiation of natural origin

(μSv)

Source	Average	Range
Cosmic radiation	300	280–310
Terrestrial gamma-rays	400	200–1000
Radon and thoron decay products	800	100–10,0000
Other internal radiation	370	200–400
Total	1870	1000–100,000

Table 2 Average annual dose from weapons fallout (μSv)

External irradiation	1.4
Intake	
Carbon-14	3.8
Strontium-90	1.4
Caesium-137	0.3
Total	6.9

Table 3 Typical dose to adults in the UK as a result of the Chernobyl reactor accident (μSv)

	First year	All years
England	25	30
Wales	70	95
Scotland	90	160
Northern Ireland	100	170
UK	35	50
Wet areas	190	270

Table 4 Annual dose from discharges (μSv)

	Average	Range
To sea, fish and shell-fish	1.3	0–1000
Other pathways	0.1	–
To atmosphere	0.1	–
Total	1.5	0–1000

Table 5 Average dose in the UK (μSv)

Source	Average
Environmental sources	
Natural radiation	1870
Weapons fallout	7
Discharges	1.5
Chernobyl accident[a]	50
Other sources	
Medical procedures	250
Miscellaneous sources	11
Occupational exposure	8

a The value for the Chernobyl accident is for all time. Other values are annual doses.

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THE ROLE OF LOCAL AUTHORITIES IN RADIATION MONITORING

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Introduction

It was very quickly obvious that, as a result of the release of radioactive material from the Chernobyl Nuclear Power Station, the major networks already established to monitor radioactive material were unable to cope with the volume of requests for sampling and information.

Local authorities were in the impossible position of having to respond to calls for information without having the information available. It is important to realise that local authorities are normally the first official body to which local residents turn for advice and guidance. In the aftermath of Chernobyl, Councils were not able to respond as they would wish. It is this inability to respond that has prompted a number of authorities to introduce radiation monitoring schemes in their areas. There were a few local authorities who could respond and their monitoring schemes have provided the basis for the development of a national local authority monitoring network.

Existing Schemes

One of the most widely known schemes is the Radmil programme (Radiation Monitoring in Lancashire). This scheme involves sixteen local authorities monitoring background radiation - using thermoluminescent dosemeters - and radioactive contamination of foodstuffs via an agreed sampling programme. The analysis is undertaken by the University of Lancaster. The scheme has been in operation for a number of years and even before that Lancaster City Council had its own local programme. Radmil was developed to provide information on levels of radiation and radioactive contamination in and around Lancashire with particular reference to the Sellafield and Heysham sites. The scheme provides valuable local data and allows the local authorities

to respond to changing local patterns and to requests for information from the public in a positive and informed manner. This programme was used as the first model for a national scheme.

Proposed Schemes

In order to respond adequately, authorities require information which is accurate, reliable and can be seen to be independent. The Institution of Environmental Health Officers established a working party to consider the necessity for local authority schemes and to propose an outline scheme which could be modified to suit most needs. There is a need for a variety of schemes depending on the type and geographical location of each authority.

The working party suggested that the monitoring programme should have the following aims:-

(i) to measure background radiation , establish the range of background levels and detect changes;

(ii) to provide local information;

(iii) where appropriate, to obtain information relevant to specific local issues;

(iv) to provide early results;

(v) to compare levels and trends with Government published data;

(vi) to establish links with other monitoring bodies;

(vii) to provide a monitoring service which is independent of industry or regulatory bodies thus adding to public reassurance.

(viii) to have an established system readily capable of adaptation to cope with abnormal/emergency situations.

It was felt inappropriate to recommend local authorities to

establish a detailed emergency detection capability as this would need complex equipment, continual staffing and would not, it is hoped, be used frequently. It was considered sufficient to be able to respond in the event of an emergency rather than be able to detect it.

The working party recommended that local authorities group themselves in some way (perhaps Chief Environmental Health Officer groupings) to allow better utilisation of resources. It also grouped the local authorities in terms of their proximity to nuclear installations.

There is now considerable interest in implementing and developing this national monitoring capability and the Institution of Environmental Health Officers will be collating all the results on an annual basis. This expanding role of the local authority should also be seen as part of its wider duty of public protection.

Role of the Local Authorities

Having established the local monitoring capability it is important to consider, in some detail, exactly what the local authority would do in the event of an emergency. The proposed plan is outlined in the recently published National Response Plan for Nuclear Incidents. The main framework of the new contingency plan, to cater specifically for the consequences of a nuclear incident overseas, is:-

(i) the Department of the Environment will take the lead, co-ordinating tasks relating to hazard assessment, necessary action and protective measures, and the supply of information to the public and Parliament;

(ii) the country is to be covered by a network of monitoring stations based on existing facilities. Information from these stations will be supplemented by information from mobile monitoring teams, hospitals and local authorities;

(iii) data from all monitoring sources will be stored on a central data base facility. Access to the

information will be given to involved organisations initially and to other organisations, by electronic mail, when the information has been "assessed".

The plan assumes that in the majority of cases, the DOE will be informed of the incident by the International Atomic Energy Agency; there are though contingency plans for continuous monitoring in the event of non-notification. The plan covers the country in such a way that any point is within 100 Km of a monitoring station.

Discussion

The plan at the present time only relates to the emergency situation but it is hoped that it will provide the basis for a national plan in the event of releases in this country. Does this plan go far enough? Is the role of local authorities to be seen purely as a passive respondent or should it be in a more active capacity?

In any event, local authorities should try to ensure that their expertise and experience in local matters is recognised and that the arrangements for emergencies include:-

(i) well defined roles and procedures for co-ordination and communication between government departments, local government, CEGB, NRPB etc;

(ii) quick and effective communications with local authorities to inform them of an incident and to initiate their monitoring programmes;

(iii) transference of information from local authorities to the Central Data Base Facility, NRPB, MAFF and DOE to aid the decision making process;

(iv) provision of up-to-date information to local authorities about the incident and any decisions regarding the implementation of countermeasures;

(v) recognition that local authorities have a vital role in keeping the public informed about the local implications of an emergency.

In the discussion document DOE suggests that measurements made by local authorities "would be useful additions to the data base in an emergency". Instantaneous Gamma-dose rate measurements at specific locations would be the most helpful. As many local authorities already have or plan to have this capability this could be invaluable in the event of an emergency. It is therefore recommended that local authorities which already have this facility inform the NRPB of their desire to participate. Whilst some local authorities have reservations regarding NRPB and other agencies, the information would not only assist in providing local information but could provide essential information in the event of an incident. To withhold such vital information is in no-one's interest.

The role of local authorities could however extend much further than this; it could encompass those issues which affect the day to day lives of the inhabitants and the working population, and would therefore have far wider implications than the proposed role. I believe that the role should extend into the following areas:-

(i) to provide information both on the local and national picture;

(ii) the control of food supplies through Food and Environment Protection Act and Food Act enforcement;

(iii) to provide information to local residents and the national co-ordinating agency on levels of radioactive contamination and radiation;

(iv) to provide input to local liaison committees; be consulted regarding annual authorisaton of discharges and the discharge limit: and involvement in a positive way in the overview of local nuclear installations;

(v) to provide input to the regulation of the nuclear industry through co-ordination and liaison with NRPB, NII, RCI and other regulatory bodies.

It is these role elements which are the most contentious but which are likely to lead to a safer environment and a better informed local population.

Author's note

The views expressed in this paper are not necessarily those of Manchester City Council.

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RADIATION EFFECTS
quantifying the consequences for health in the UK of the Chernobyl accident

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The relationship between exposure to ionising radiation and detriment to health is conventionally based upon the energy absorbed by the body's tissues ie the quantity known as **absorbed dose.** Absorbed dose, hereinafter referred to as dose, is the energy absorbed in a unit mass of tissue as a result of exposure to radiation and is expressed in units of Gray. Although dose is generally acknowledged to be the best predictor of effect it is by no means a straightforward relationship and is influenced by, among other factors, the type of radiation, the distribution of the energy deposited in the tissue, and the rate at which energy is deposited ie dose rate. Quantitative information about the relationship between dose and effect is obtained from the study of human populations exposed to ionising radiation. Such studies are a branch of epidemiology.

Radiation is capable of causing cancer, hereditary damage and a number of other effects for which there are thresholds below which radiation has no discernible effect. Such a threshold cannot be assumed for carcinogenesis or hereditary damage; firstly, on the grounds that there is no evidence for such a threshold and, secondly, in terms of our basic understanding of the action of ionising radiation on living tissue there is no justification to assume a threshold. This paper is concerned only with the carcinogenic effects of radiation.

The effects of radiation at low doses and low dose rates, as were experienced in the UK from the Chernobyl accident, could only be directly measured by epidemiological methods on very large populations; often far larger than are available in practice. This is because radiation induced cancers are indistinguishable from those occurring spontaneously. The lifetime risk of cancer is about 1 in 5 and so small increases resulting from radiation exposure are difficult to detect. It is therefore a matter for interpretation to deduce from human experience acquired at high doses and high dose rates, the effects that might result from exposures to low doses at low dose rates. This interpretation is a contentious issue in radiological protection.

Accidents such as that at Chernobyl, which result in widespread dispersal of radioactivity into the environment, give rise to a number of routes of exposure to radiation and thus to further interpretational complications. Prior to the Chernobyl accident all the routes of exposure had been anticipated since the radioactive materials released from such accidents are subject to control as routine discharges from the nuclear power industry. Thus, their behaviour once in the environment, including transfer to and through the food chain, has to be relatively well understood in order to determine the relationship between the risk to the public deemed to be acceptable for the routine operation of the nuclear power industry, and the discharge rates concomitant with this risk. However, such model relationships that form the basis for this aspect of radiological protection are not necessarily suitable to make retrospective estimates of the health detriment in the case of an accident. The reason is partly that such models usually incorporate substantial elements of caution, entirely appropriate in the context of planning radiological protection, but which may result in an over estimation of the health effects when applied retrospectively in a particular situation.

It is also important to remember that some schemes for radiological protection necessarily consider effects averaged over the population, and although exposure may in practice be limited by the consideration of those most heavily exposed, ie critical groups, the estimation of risk involves only averages. Thus, while these procedures provide an acceptable means of limiting average risk to the population to a lower than chosen level, they do not provide a true reflection of the health detriment and its distribution among the various subgroups in the population, eg the young, the old, males, females etc. Such models do, however, help to indicate which routes of exposure are likely to be dominant.

The principal constituents of the Chernobyl cloud as it passed over the UK are given in Table 1. Three major factors determine the content of such radioactive clouds; these are the content of the reactor core, and the volatilities and radioactive half-lives of the nuclides. The content of the reactor core depends largely on the degree of

'burn-up', ie the extent to which the fuel is converted to fission products, and the state of the reactor at the time of release. High 'burn-up' gives rise to high levels of fission products, which in many cases are markedly more volatile than the fuel itself. Given the chemistry of the fission product mix and the relative volatilities of the nuclides, the isotopes of iodine, ruthenium, tellurium, caesium and the noble gases, xenon and krypton, dominate in terms of the released radionuclides (see Table 1). However, in a reactor operating at the time of an accident, as was the case at Chernobyl, very short-lived isotopes will also be present, for example iodine-132 to iodine-135, the half-lives of which range from 0.035 days to 0.85 days. These do not appear in Table 1 because of the time that elapsed between release and the arrival of the cloud over the UK.

During the passage of the Chernobyl cloud there were four main routes for exposure of people; namely, external exposure from immersion in the radionuclide cloud, internal exposure from inhaled radionuclides, and external exposure from activity deposited on the skin and on the ground and other surfaces. The latter two routes, involving deposition of radionuclides are influenced by rainfall which was heavy in Cumbria and parts of Scotland, but absent in most of England. This is apparent from the measurements of ground deposits of caesium isotopes made after the passage of the cloud (see Table 2). Clearly, the extent of exposure externally will depend upon the amount of time spent out of doors during the passage of the cloud, and the extent to which radionuclides are inhaled will depend upon this and the volume of air breathed during the exposure. Thus, the dose received by someone engaged in work or energetic sport out of doors is likely to be greater than that to someone asleep indoors.

In connection with assessing the significance of these types of exposure the concept of **committed dose** is important. Unlike external exposure from the cloud, deposited radionuclides continue to irradiate those in the vicinity after the cloud has passed. In particular, ground deposits, if of long-lived radioisotopes such as caesium-137, will remain in the environment for many years.

This has a number of implications. Firstly, the exposure of individuals will continue for several years, maybe for the remainder of the individual's life. Thus in assessing dose to individuals this continuing exposure must be taken into account. Furthermore, radionuclides from Chernobyl remaining in the environment can irradiate generations as yet unborn, so leading to a potential health detriment of considerable duration. In this presentation attention is confined to the effects in the current generation and for reasons that will become apparent later no attempt has been made to estimate a detriment to future generations. The concept of committed dose also applies to internal irradiation which continues until, for practical purposes, either biological elimination or radioactive decay removes the radionuclides from the body.

As well as providing external exposure deposited radioactivity leads to contamination of the food chain either directly through contamination of fresh vegetables, or indirectly by its presence in dairy products, meat etc following the ingestion of contaminated pasture by farm animals. Given the dietary importance of fresh milk in the UK this is a major route of entry for certain radionuclides that are metabolised in mammals, in particular isotopes of iodine and caesium.

The estimation of external exposure from the cloud and from deposits on the skin and ground should be relatively straightforward, based mainly on direct measurements of dose and assumptions regarding the behaviour of potentially exposed individuals. Estimates made by the NRPB are given in Table 3.

Internal exposure on the other hand represents a more complex problem. Two routes of internal exposure, inhalation and ingestion, have been identified. If the inhaled radionuclides are insoluble then a proportion of the radioactive material will be retained in the lung and so primarily irradiate that organ. If, on the other hand, it is soluble then it will be rapidly transferred to blood and then, if metabolically active, to other tissues. Much the same applies to ingested materials which, if insoluble, will irradiate the gastro-intestinal tract during their passage but,

if soluble, will cross the gut wall to the blood. Thus the nuclides in Table 1, other than the isotopes of iodine and caesium, when inhaled will primarily affect the lung. (^{132}Te is an exception because it is soluble and readily taken into blood. Tellurium is not metabolically active and so is fairly rapidly eliminated from the body. However, ^{132}Te decays to ^{132}I which is metabolically active and such decays occurring whilst tellurium is in the blood will result in irradiation of the thyroid gland by ^{132}I. In comparison to ^{131}I the dose from ^{132}Te/^{132} I was small in the case of the Chernobyl accident.) The isotopes of iodine and caesium being soluble and metabolically active when inhaled or ingested will be taken into blood and then retained in the body's tissues. Ingestion of isotopes other than caesium and iodine do not, in general, give rise to doses either to the GI tract or other tissues that are significant compared to lung doses arising from inhalation.

In Table 4 estimates of doses from the inhalation of some of the cloud-borne radionuclides are given. As can be seen those affecting primarily the lung, ie ruthenium-106 and barium-140 gave doses of only a few μGy when integrated over a life-time. For the average member of the UK population doses to the lung from α-emitting radon (a natural radionuclide) and its daughters approach 1mGy annually. Alpha-particle radiation is usually regarded as more damaging per unit dose than the β and γ-rays emitted by fission products and so it is likely that radionuclides from Chernobyl may have resulted in a life-time risk increment at most of 1% of the risk of lung cancer from natural radon exposure.

The risks resulting from the inhalation and ingestion of iodine and caesium will be discussed below; it is these nuclides which provide the major exposure from Chernobyl.

<u>Isotopes of Caesium</u>

The isotopes of caesium identified at Chernobyl were caesium-134, caesium-136 and caesium-137. ^{134} Cs and ^{137}Cs are relatively long-lived (half-lives 6 years, and 30 years respectively). ^{136}Cs is relatively short-lived (half-life 13 days) and is therefore of small consequence in

comparison. Caesium compounds are usually soluble and they behave in living tissues in much the same way as potassium. Thus inhaled or ingested caesium is rapidly taken into blood and then into muscle from which it is eliminated at a rate dependent upon age. For an infant aged 6 months, about half a single intake of caesium will be eliminated within 20 days but for the adult the half-time for elimination is about 100 days (Baverstock, 1987). Because it is widely distributed in the body the caesium gives rise to more or less uniform exposure of the whole body even though much of the radiation emitted is of short range (β -rays). Caesium isotopes deposited on the ground will also give more or less uniform exposure to the bodies of those in the vicinity because longer ranged and penetrating x-rays are also emitted.

In the areas of the UK where there was rainfall during the passage of the cloud, ground deposition contributed significantly to the whole body exposure. Heavy ground deposition also meant that local food stuffs were more seriously contaminated in rainfall areas. However, subsequent measurements of caesium in the bodies of inhabitants of those areas seem to suggest that locally produced food is not necessarily locally consumed, and the levels of caesium are below those predicted from models for food consumption (Fry et al., 1987). It is in fact most unlikely that any member of the UK population will receive, over the remainder of their lives, a dose equal to or exceeding that which they receive from average natural background radiation to the whole-body in a single year, ie 1 mGy. The principal sources of natural background exposure are radiation of cosmic and terrestrial origin and internal exposure from ingested and inhaled radionuclides of natural origin. Exposure of the whole body is primarily from β - and γ -rays, and is comparable to the exposure from fission products. A small component of cosmic radiation is from heavy charged particles which may be more effective per unit dose. The average annual dose from natural background radiation to the whole body is about 1 mGy. Exposure to radon enhances the dose to the lung and is not included in this estimate.

It is this unavoidable route of exposure to ionising radiation

- natural background exposure - that provides the best yard stick against which to measure the impact on health in the UK of this aspect of the Chernobyl accident. It is expecting far too much of our ability to interpret human epidemiological studies to give reliable estimates of detriment at such dose levels, and indeed, it is dishonest to claim to be able to do so.

Natural background radiation levels vary considerably from place to place yet there is little or no compelling evidence of an increase in cancer incidence or mortality associated with these variations. This does not mean to say that such exposures do not result in cancer, only that any risk is effectively masked by other factors affecting cancer incidence, ie that the risk is comparable to, or smaller than that attributable to other factors.

As noted above, caesium from Chernobyl will remain in the environment for generations to come, but doses to individuals belonging to future generations will be much smaller than to those alive at the time of the accident. Since it is not possible to quantify the health detriment to those immediately affected in the UK there is no point in attempting to do so for future generations. The same comparisons with natural background radiation will apply, only more so.

Isotopes of Iodine

As was noted above, because of the time that elapsed before the cloud reached the UK the predominant iodine isotope detected in the cloud over the UK was iodine-131. Iodine-131 has an 8 day half-life and is present in such fallout in soluble forms. Within a day of deposition iodine-131 can be found in the milk of cows feeding on contaminated pastures. Peak contamination of milk usually occurs about 3 days after deposition. The values for peak activities of ^{131}I in milk for various parts of the UK are given in Table 5.

In humans ingested iodine crosses the gut wall efficiently and is rapidly concentrated in the thyroid gland from which it is cleared with a half-life of between 6 and 8 days depending

on age. The **maximum** concentrations observed in milk following the Chernobyl accident were such as to be able to give an absorbed dose of more than 10 mGy to the thyroid gland of an infant drinking this milk (see Table 6). Note that overwhelmingly the most important route is from ingestion and this is based upon the consumption of 0.7 1 and 0.5 1 of fresh cows' milk daily for the infant and adult respectively. **Average** doses received by the inhabitants of Galloway, Dumfries, Clwyd, Gwynedd and Cumbria were about half this value. Iodine-131 does not occur naturally in the environment and so the thyroid gland is not subject to dose enhancement from natural radiation; it receives the same as the rest of the body, ie about 1 mGy. Thus, from this one route of exposure there may well have been some children in the UK receiving a dose to the thyroid equivalent to up to ten years of natural background radiation. This may not be considered a negligible increment in the unavoidable risk from natural background radiation as was the case for the isotopes of caesium. In fact, there is evidence from a survey of children irradiated in Israel for various scalp conditions that absorbed doses of X-rays to the thyroid of about 100 mGy may well have given rise to a detectable excess of thyroid cancer. These data need careful interpretation since, for example, in spite of this evidence, there is no compelling evidence from the study of humans given ^{131}I for therapeutic purposes that β-rays from iodine-131 are carcinogenic. This is an unresolved paradox but nevertheless it seems prudent to assume, in view of the X-ray results, that exposure to iodine-131 can cause cancer.

On this assumption the Israeli study can be interpreted (Baverstock, 1986) as suggesting that for the 30 years following exposure of the thyroid gland the spontaneous risk of thyroid cancer is increased by 2% for a dose of 1 mGy. Thus, some infants in the UK might have had their spontaneous risk of thyroid cancer increased by more than 20%. This does not necessarily imply a large number of thyroid cancers since the spontaneous risk in the first 30 years of life is only 1 in 10,000. Adults drinking the same milk in only slightly smaller quantities incur a dose ten times smaller. This is because the masses of their thyroids are about 10 times greater than those of the six months old infant. If the inferences drawn for children from the Israeli

study can be extended to adults, then for the same environmental contamination levels adults incur up to a 2% increment in their spontaneous risk of thyroid cancer for the 30 years following exposure. However, the spontaneous risk for adults is considerably higher (about 1 in 1000). It should also be noted that only about 5% of cases of thyroid cancer prove fatal.

In their recommendations on the criteria for controlling doses from accidental releases of radionuclides the ICRP (1984) state that it is, in the first instance, the risk to the individual that should be considered in deciding whether to implement countermeasures. This is generally regarded as referring to the 'absolute' risk to the individual, ie the absolute probability of causing cancer, rather than the 'relative' risk, which is the increment on the spontaneous risk as I have calculated. However, it could be argued that a lower spontaneous risk for a disease during a period of life is a natural benefit and something not necessarily lightly parted with. In practice, the isotopes of iodine are likely to be important in any exposure resulting from an accidental release of radionuclides from a reactor and it may be appropriate to give consideration to the disproportionate risk (in relative terms) incurred by the very young. Fortunately, countermeasures to control exposure to iodine-131 are not costly, neither do they themselves carry a substantial risk.

In the Netherlands a ban on grazing cattle was imposed on 3rd May, only one day after the cloud reached that country, and well before levels of ^{131}I reached those at which intervention would be required (CCRX, 1986). The ban was lifted on 8th May. In an assessment of the effect of counter-measures taken in European countries, Morrey et al (1987) estimated that the grazing ban in the Netherlands saved 50% of the dose from ^{131}I to those potentially most heavily exposed, and some 20% of that to the Netherlands population as a whole. In the case of widespread contamination by short-lived isotopes such as ^{131}I it may be necessary to take action before the full impact of the contamination can be assessed, if such action is to be effective.

As things turned out, the Chernobyl accident (the most

serious civil nuclear accident to date) had remarkably little impact on the UK and held few surprises. An exception is the persistence of caesium in sheep grazing upland pastures. The ban on the slaughter of such sheep was the major intervention measure taken in this country. The reasons for the persistence can be understood in terms of the greater retention of caesium by acidic soils, ie those typically found in upland pastures, compared to those less acidic and characteristic of lowland regions. We should not, however, be complacent over the potential consequences to health of such accidents occurring either abroad or in the UK. Firstly, in this instance several days elapsed following the accident before any radioactive material arrived in the UK, thus allowing short-lived radionuclides to decay and for considerable dilution of the cloud to occur. Secondly, rainfall was sporadic and confined to relatively small areas of the country. These factors worked together to reduce considerably the impact of the accident. Our neighbours in parts of Scandinavia and other parts of Europe were less fortunate.

References

Baverstock, KF, (1986). A preliminary assessment of the consequences for inhabitants of the UK of the Chernobyl accident. International Journal of Radiation Biology. 50 iii-xiii.

Baverstock, KF, (1987). Half-time for clearance of isotopes of casesium in man. In 'Age-related factors in radionuclide metabolism and dosimetry'. Eds. Gerber GB, Metivber H, and Smith H. Martinus Nijhoff, Dordrecht, for the CEC.

CCRX (1986). Radioactive contamination of the Netherlands as a result of the nuclear reactor accident at Chernobyl. Ministry of Housing, Physical Planning and Environment, The Hague.

Crick, MJ, and Simmonds, JR, (1987). Chernobyl reactor accident: revised estimates of radiation doses in the UK. Submitted to Nature.

Fry, FA, and Britcher, A, (1987). Doses from Chernobyl radiocaesium. Lancet ii 160-161.

Fry, FA, Clarke, RH, and O'Riordan, MC, (1986). Early estimates of UK radiation doses from the Chernobyl reactor. Nature 321 193-195.

ICRP (1984) Protection of the public in the event of major radiation accidents, principles for planning. Annals of the ICRP 14.

Morrey, M, Brown, J, Williams, JA, Crick, MJ, Simmonds, JR and Hill MD (1987). A preliminary assessment of the radiological impact of the Chernobyl reactor accident on the population of the European community. CEC, Luxembourg.

TABLE 1

TIME INTEGRATED RADIONUCLIDE ACTIVITY CONCENTRATION IN AIR REPRESENTATIVE OF ENGLAND

(Bq seconds per cubic metre)*

Nuclide	Bq s per m^3
I-131	4.3 10^5
Te-132/I-132	8.6 10^5
Ru-106/Rh-106	6.5 10^4
Cs-134	3.2 10^4
Cs-136	1.5 10^4
Cs-137	6.5 10^4
Ba-140/La-140	3.2 10^4

* Activity is measured in Bequerels (Bq). 1 Bq is 1 radioactive decay per second. This table thus gives the total number of decays occurring in a cubic metre of air during the passage of the cloud.
(from Crick and Simmonds 1987)

Table 2

INITIAL GROUND DEPOSITS OF ISOTOPES OF CAESIUM

Nuclide	Range of values in Bq per square metre	
	Highest	Lowest
	(Scotland, Cumbria & N. Ireland)	(England & Wales)
^{137}Cs	2000	100
^{134}Cs	1000	50

(from Crick and Simmonds 1987)

Table 3

ESTIMATES OF DOSES TO THE WHOLE BODY FROM

GROUND DEPOSITED RADIOACTIVITY

Estimated	Initial dose rate uGy per hour	integrated to 1 year uGy	integrated to May 1991 uGy
Fry et al (1986)			
"north"	.6	160	560
"south"	.1	10	30
Crick and Simmonds (1987)			
Cumbria	.45	28	(100)
England & Wales	.12	3.4	(12)

Figures in brackets were not given but are estimated on the basis of the extrapolation used by Fry et al (1986) to obtain the dose integrated over 5 years.

Table 4

DOSES RECEIVED FROM INHALATION OF THE CLOUD

Nuclide	Dose		Tissue at Risk
	Infant uGy	Adult uGy	
I-131	80	30	Thyroid
Ru-106	40	10	Lung
Cs-137	0.05	0.1	Whole body
Ba-140	7	2	Lung

Table 5

REPRESENTATIVE PEAK ACTIVITY CONCENTRATIONS

IN MILK (Bq per litre)

Region	I-131	Cs-134	Cs-137
Cumbria Clwyd & Gwynedd Dumfries & Galloway	200	100	200
Scotland	70	30	60
England	50	5	15
Wales	20	5	15

(From Crick and Simmonds 1987)

Table 6

MAXIMUM THYROID DOSE RECEIVED IN THE UK FROM CHERNOBYL[1]

	DOSES (uGy)	
	Infant	Adult
EXTERNAL SOURCES:		
From cloud	0.1	0.1
From ground	560 (100)[2]	560 (100)[2]
INTERNAL SOURCES:		
From inhalation	100	30
From ingestion	13000	1000
TOTAL	14000 (13000)	1600 (1100)

(1) assuming 400 bq/l peak activity of iodine-131 in fresh cows' milk consumed at the rate of 0.7 l/day by a six month old infant and 0.5 l/day by an adult.

(2) revised estimate based on the 1987 estimate (see Table 3)

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INTERNATIONAL REACTOR PROGRAMMES

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SUMMARY

The place occupied by nuclear power in the world energy scene is reviewed and the need for nuclear power is emphasised. The problems and constraints affecting the deployment of commercial nuclear power are examined. It is concluded that if it is to reach its full potential the nuclear industry must gain the confidence and acceptance of the public and some of the challenges inherent in doing this are highlighted.

INTRODUCTION

It is now 45 years since the world's first nuclear reactor went critical and commercial nuclear power is 33 years old. The world's first electricity producing power reactor was commissioned in 1954 at Obninsk near Moscow in the Soviet Union, shortly followed by the commissioning of Calder Hall in the UK, the Shippingport PWR in the USA and the French gas cooled reactors at Marcoule (Figure 1). Nuclear power has come a long way from those small beginnings until today there is a mature nuclear industry, albeit one faced by controversy. Despite present difficulties, there seems little doubt that nuclear power will continue to play a major, but not exclusive, role in the energy scene - at least in the developed world - for electrical power generation. Nuclear power will co-exist with coal and other energy sources including some of the 'renewable' sources which have yet to reach the same state of development as nuclear power.

WHAT HAS BEEN ACHIEVED

Today, when so much is heard about the slowdown in nuclear developments, it is easy to overlook the impressive achievements made since 1954. Perhaps the most striking feature of the initial period of development was the

confidence shown in the industry and the rapidity of the nuclear build up to meet a substantial share of electricity generation. This involved not only building hundreds of nuclear power stations but also the infrastructure to provide them with fuel, to maintain them, to store and dispose of the waste and to ensure their safety.

From the small beginnings illustrated in Figure 1, there were by the end of 1986 397 reactors of 273.7 GW capacity in operation in 26 countries with a further 141 reactors of 123.7 GW capacity under construction (1). Thus nuclear power has an important role in electricity generation in many nations (Figures 2 and 3).

Let us look in a little more detail at the reactor types which are in operation today. (Figure 4 based on May '86 data, 2). Initially many reactor systems were tried worldwide but experience has narrowed the choice so that today light water reactors (PWR and BWR) are the majority choice. PWRs are the dominant system and this dominance can be expected to increase; building Sizewell B thus brings the UK into line with the majority. Heavy water reactors such as CANDU and graphite moderated gas-cooled reactors (Magnox, AGR) together account for 10% of reactors. The Russian RBMK reactor (graphite moderated water cooled) is unique to the Soviet Union. Finally, there is as yet only a small role for Fast Reactors but this must be expected to grow in the next century.

In total nuclear power provided 15% of the world's and 17% of the non-communist world's electricity in 1985; the nuclear share reached 30% in the EEC (3-5). Figure 5 shows how the contribution of nuclear power to meeting the West's primary energy requirements for electricity generation has risen from the modest share of 1965 to today's important contribution.

ADVANTAGES OF NUCLEAR POWER

This rapid growth in nuclear power across the world has come about because of nuclear power's clear economic advantages. Figure 6 illustrates this advantage by comparing the costs of generating electricity (looked at over the entire

station lifetime) of coal and nuclear stations in a number of countries. The costs shown (6) are based on utility perceptions of future coal and nuclear generation costs. The nuclear costs are for PWRs commissioned in 1995 and assume a conservative 25 year lifetime and 70% average load factor. Since this comparison was made world coal prices are now thought likely to be lower, and although this tends to diminish the cost advantage of nuclear power, in most countries it still leaves nuclear with a clear advantage over coal.

Nuclear power also offers environmental advantages in that it avoids the emissions associated with coal burning including SO_2, NO_x, CO_2, particulates and polycyclic organic matter which may itself be carcinogenic. The importance of nuclear power in reducing these emissions can be seen by a simplified example based on the fact that in 1986 nuclear power worldwide saved the burning of 500 million tonnes of coal or its equivalent.

Figure 7 shows the emissions and waste products involved in producing electricity from 500 MTe of coal. The 1000 MTe of CO_2 emissions saved represents about 5% of the carbon added annually by fossil fuel burning and a quarter of that due to forest removal (given in 7). A feel for the importance of the NO_x emissions saved (4 MTe) is that they correspond to about a fifth of the NO_x emitted in Europe (Ref.8).

The estimated 6 MTe of SO_2 saved (Figure 7) would correspond to about a quarter of European emissions. It does, however, assume the use of one of the FGD processes (limestone/gypsum). Such processes are by no means in universal use and imply an economic penalty. Without them sulphur emissions would be much higher; typical efficiencies for SO_2 removal are around 90%. The 6 MTe is therefore a minimum saving.

A potential problem with coal fired power plant with FGD is the disposal of wastes and by-products stemming from combustion and the gas clean-up process. Nuclear power too has waste products, of which more later, but the volumes involved are comparatively small.

PROGRESS HELD BACK

Despite the impressive progress of the past and despite the economic and environmental advantages mentioned above, there are many who question the need for and future of nuclear power. They point to the significant loss of public support and the political opposition to nuclear power in a number of countries (eg Denmark, Sweden, Austria) and to the recent decline in the rate of ordering of nuclear power stations. This latter I will remind you is largely a result of the reduced rate of growth of electricity demand arising from slower economic growth over the past decade; this has been reflected in less bullish forecasts of future growth in nuclear capacity. Figure 8 illustrates a consequence of this, showing orders net of cancellations.

Critics of the nuclear industry often point out that in the USA there have been no new nuclear reactors ordered since 1978. Furthermore, from 1972-85 at least 120 GW of nuclear capacity was cancelled (9) although at the end of 1986 some 19 reactors were still under construction (1). But this is to give only one side of the picture; few major coal-fired stations have been ordered since the late 1970s. A key reason in both cases was a massive over-ordering during the mid-1970s by the American utilities (9) with a failure to anticipate the recession of the late 1970s. Moreover, the American system of regulating tariffs discourages new construction to replace old expensive-to-run plant, since it is easier to justify tariff rises due to higher fuel costs than to recover capital costs. One consequence especially in the smaller US utilities is to encourage the use of less efficient fossil plant at the expense of more capital intensive alternatives. Lengthening construction times due to safety and licensing problems have also significantly increased costs and eroded the competitive position of nuclear power.

French experience contrasts strongly with that in the USA. Although the French have about half the number of reactors (France 49 reactors of 44.7 GWe, USA 99 reactors of 84.6 GWe) they have been able to benefit greatly from standardisation via three 900 MWe and two 1300 MWe PWR series.

However, France is perhaps an exception. Loss of confidence in nuclear power is very real in many countries. Before discussing the reasons for this and how this confidence may be regained, lest us look first at what doing without nuclear power would cost us and examine the promise that full use of nuclear power still holds out to us.

THE NEED FOR NUCLEAR POWER

The need for nuclear power arises from the need to meet a growing world demand for energy in the most economic manner. We expect continued economic growth and the consumption of energy is broadly related to economic output. Thus economic growth can be expected to result in growth in the demand for energy. This will be less in countries such as those of Western Europe, the USA and Japan, whose economic growth now depends less on energy intensive industries and where energy consumption in some sectors of use will saturate, but it will be more in the developing countries where growth of energy consumption starts from an average base only a fifth that of Europe and Japan, and a tenth that of the USA. World population, rising at 2% p.a., will add to this growth in energy demand.

Patterns of energy use are likely to change, in particular electricity demand is likely to grow more rapidly than energy demand generally in the developed countries. The efficiency of energy use will continue to improve but this merely slows down growth in energy demand.

The growing demand for energy has been met in the past by expanding world supplies of fossil fuels and, especially since the 1950s, by cheap and easy-to-produce oil and natural gas (Figure 9). Supplies of these fuels will continue to rise to meet demand, but the resources are finite and, sooner or later, supplies of oil will not be enough to meet demand. Prices will rise, a process which may be accelerated by the concentration of available supplies of oil and gas into fewer hands (OPEC has 67% of oil reserves while OPEC + USSR has 75% of gas reserves, 10). These price rises will affect the prices of other fuels. Even though world resources of coal are large (the ratio of reserves to current production is

about 200 years compared with about 35 years for oil and 60 years for gas), there are likely to be constraints on the rapid expansion of large scale trade in coal, and coal will be increasingly in demand for conversion to other fuels such as synthetic liquids and gases and for use as a chemical feedstock. Its price too will therefore rise.

The process of resource depletion is inevitable though its timing is uncertain; new discoveries (not included in the reserve to production ratios quoted above) will delay the time when resource depletion becomes a serious problem. Similarly improvements in the efficiency of energy utilisation and the use of renewable energy technologies, including those for electricity generation, will help but alone they are not enough.

Today nuclear power conserves fossil fuels and thereby reduces pressures on resources. In doing so it helps keep fossil fuel prices down. In the longer term, but almost certainly within the lives of power stations now being built, pressures on resources would become untenable if nuclear power were not available; at the same time environmental consequences from fossil fuel burning could be of increasing concern.

There would be a heavy price to be paid for rejecting nuclear power. Currently around one third of the EEC's electricity is produced by nuclear power: replacing it would require some 130 mtoe/year of more costly alternatives, that is the equivalent of the whole of the UK's oil production.

By 2025 some 9000 TWh/year of electricity might come from nuclear power: without it some 2000 mtoe/year of extra fuel could be needed equivalent to discovering and consuming a new oil field the size of the North Sea about every two years. Improvements in energy efficiency and exploitation of hydro and other renewable energy resources would not be sufficient to insulate the economy from price rises. Everyone would suffer from these high energy prices but those least well able to afford it - the developing countries - would suffer most.

Contrast this situation with that offered by the full use of

nuclear power. By adding a further major power source to the available mix the situation is greatly eased. In saying this, I believe all energy resources, including the "renewables", will be needed and in that sense they are not in competition but should be seen as complementary. Using nuclear power would continue to minimise pressure on other resources and help hold down energy prices. Indirectly this would benefit even those countries without nuclear power.

For this picture to hold true, nuclear power must offer a plentiful resource base. When used in thermal reactors, uranium can make a useful but not decisive contribution to long term energy supply. (Broadly speaking known uranium resources used in thermal reactors are similar to the oil resource).

This situation is changed markedly by the advent of the Fast Reactor; Fast Reactors utilise uranium some 60 times more efficiently than thermal reactors and thereby greatly increase energy resources available to man. The difference this makes is illustrated in Figure 10.

The Fast Reactor offers major strategic and economic benefits:

- security of supply; the Fast Reactor makes countries energy independent if they have a small indigenous supply of uranium or even if they have already imported some.

- economic benefits; Fast Reactor generating costs are already close to PWR costs and it is a proven system. Its modest uranium requirements mean that even when uranium prices rise markedly there is an effective cap on generating costs.

These advantages mean that only only is nuclear energy able to offer comparatively cheap electricity now through thermal reactors but that, via the Fast Reactor, it can continue to do so for a long time to come. For the future, as fossil fuel prices eventually rise, the economic advantages of nuclear power will increase; in time the low fuel cost component of Fast Reactor generating costs will emphasise the cost advantage of nuclear electricity.

Cheaper energy, both directly as electricity and indirectly via reduced pressure on fossil fuel resources, will help promote economic growth which in turn leads to better employment prospects. A corollary is that any country going it alone on an anti-nuclear strategy, by losing the benefit of cheap nuclear electricity, places itself at a competitive disadvantage with a cost to jobs.

WHAT IS HOLDING BACK NUCLEAR POWER

Undoubtedly concern over safety and the environment are major factors which hold back nuclear power. Major aspects of this are concern over:

- reactor safety
- safety in normal operation
- dealing with wastes

Let us look at each of these in turn.

Reactor Safety

The safety strategy for nuclear reactors is 'defence in depth'. Reactor design and operation must provide protection against the radiological consequences of normal operation and fault conditions. It must contain any accident to ensure that the public is not involved.

Defence in depth is achieved by:

- selecting a good design concept having intrinsic characteristics which provide inherent protection but then recognising that this alone is not enough; things can go wrong;

- providing engineered safety features intended to prevent, limit, terminate or mitigate faults. These features incorporate diversity and redundancy to ensure that there is a very low probability of their failing to perform if required;

- recognising how operators work and getting the safety 'culture' right. This covers the whole management system

including sound management, safety and operational procedures and highly trained operators. It recognises that mistakes can happen so that the whole edifice of safety does not depend on the operator alone; nor should it place too much pressure on him.

In most countries these features are scrutinised by a regulatory body independent of the operators and designers.

The Russian account of the Chernobyl accident have placed the blame on human error as the primary factor (eg 11,12) but in fact all the above lines of defence were breached (eg 13, 14). Specifically, the accident was caused by:

- faults in reactor design (inherently unstable in some operating regimes): this was the major shortfall;

- faults in engineering implementation of the design (insufficient safety systems);

- failure to understand the fallibility of the operators (a 'colossal psychological mistake' in the words of Mr Legasov, the head of the USSR delegation to IAEA at Vienna);

- inadequate operator training, as recognised by the Russians (training centres have been set up at Smolensk (RBMKs) and Novo Voronezh (PWRs) for staff training using special simulators, 15).

A potentially unstable reactor such as the RBMK would not have been licensed in the West. Indeed the Chernobyl design was so deficient that it cannot be seen as typical of nuclear power stations in the West. Thus judging nuclear power on the basis of Chernobyl is akin to judging aviation safety on the basis of a single aeroplance of unstable design, prone to stalling, badly engineered and incompetently flown.

There is, however, no room for complacency. The nuclear industry cannot afford another Chernobyl; it reaffirms our view that it is essential to ensure that any accident, however great, does not affect the public by exposing them to radiation. The alternative is that nuclear power will just not be acceptable as an energy source.

How, then, do we assure ourselves of safety? The need to assure ourselves that the reactor is acceptably safe is recognised at each of the stages from the initial design concept through operation to final decommissioning. The essential element of safety assurance derives from developing the design to reduce the risk of failure of safety related plant to acceptably low levels and carrying out various analyses and appropriate R & D (eg concerning behaviour during fault conditions). The fundamental approach is to:

- identify all potential fault conditions by type and estimate their frequency of occurrence;

- determine how each fault becomes apparent and how the reactor would be shut down;

- study the shut down process and heat removal in each case.

Doing this involves two complementary methods; the deterministic approach of examining all potential faults and fault sequences; and the probabilistic approach via event and fault tree analysis.

This procedure enables the plant to be designed to give the level of protection demanded by society. More and more improbable events can be considered until a point is reached where the probability of the assumed situation occurring is so remote as to make unnecessary any further safeguards.

The outcome is a judgement of the probability of accidents leading to major releases of radioactivity coupled with meeting the stringent target for each reactor of less than once in a million years. To ensure no single accident sequence dominates the design, the probability of any single accident is less than once in 10 million years. In Sir Frank Layfield's words (16) this means the reactor is "sufficiently safe to be tolerable".

No one can say an accident will never happen; there is always some possibility, however remote. If there is a large release of radioactivity in such an accident then some people

may die immediately or within weeks or months, others may suffer radiation doses well above background while relatively large numbers would receive enhanced doses. The effects of these excess doses of radiation in terms of the cancer deaths they induce can be estimated. This enables us to see Chernobyl in perspective.

Chernobyl was a very great disaster; notwithstanding the "statistical" as opposed to "named individual" nature of the long-term deaths it ranks with the world's worst man-made disasters. (Table 1).

No one should belittle the Chernobyl disaster; it was a very major disaster. Nevertheless, it was no more than that and the nuclear industry is not alone in having to recover from disasters. The chemical industry did not cease operation after Bhophal and airliners fly the day after a major accident.

There are other perspectives; for example coal not mined means miners not killed; uranium mining kills far fewer per unit electricity than does coal mining. Statistically nuclear power worldwide saves about 250 accidental deaths a year assuming 1 miner killed per 2MT of coal mined (cf 17, the figure is roughly mid-range for the UK but subject to uncertainty); and nuclear power avoids the debilitating occupational diseases of coal mining. Finally, industrial accidents of all types, including nuclear accidents, pale into insignificance compared to natural disasters such as disease and famine in the developing world; much of this disease would be avoidable with higher living standards which depend in part on adequate energy being available.

Safety in Normal Operation

Many people undoubtedly fear radiation. It is undetectable by the human senses and yet can cause cancer and genetic mutation. However, people do not always realise the extent to which they live in a radioactive world; life has evolved in a sea of radiation. Radiation comes to us from space and is present in the rocks and soil, in the air we breathe, in our homes and places of work. This is shown in Figure 11, which also shows that the main artificial source is medical,

though even this is smaller than radon, a natural source. In comparison with all these the nuclear industry makes but a very small contribution to overall exposure.

Medical radiation doses and radiation from radon, even in the home, do not evoke the same concern as the much smaller doses from the nuclear industry. The fact that people see risks as greater than they really are colours their attitude to nuclear power.

The vast majority of the potentially most harmful radioactive wastes from nuclear power technology are contained in the irradiated fuel and hence the reactor or in spent fuel in the fuel cycle. They are not automatically and immediately released into the environment. The aim in deciding when, and how, to release them to the environment (which may be over millenia) is to ensure no-one receives a significantly increased exposure as a result. In doing this the concept of a "critical group" is used; the judgement is not based on average exposure.

Radioactive wastes have to be isolated from the environment until their radioactivity has decayed to a negligible level. The plan is either to package them if they are solids already, or to convert them into solid durable forms. The fact that the volumes of waste involved are small by industrial standards (Figure 12) greatly simplifies their management (18).

Waste management is related to the type of waste being dealt with. The three broad categories are:

- High level or heat-producing waste (HLW); liquid wastes from fuel during reprocessing which contains transuranic elements as well as fission products; it comprises both highly radioactive, heat-generating and long-lived components. (Some countries such as the USA do not reprocess but irradiated fuel may be considered as HLW and should meet the same disposal requirements, 19). The liquid is vitrified, ie made into solid glass blocks, and the plan is to store these for 50 years (say) when radioactivity and heat production is much reduced. They may then be treated in much the same way as the next category of waste.

- Intermediate level wastes (ILW) comprise firstly alpha-bearing wastes which are wastes contaminated with long-lived alpha emitting nuclei and arise mainly from spent fuel reprocessing and mixed oxide (UO_2-PuO_2) fuel fabrication and, secondly, wastes with significant beta/gamma activity but low alpha activity (eg resilns from LWR primary coolant circuits). These wastes will be immobilised prior to disposal. Various alternative disposal methods are being evaluated and in some cases implemented; these include deep underground disposal, a deep store under the seabed approached via a tunnel and a cavern hollowed out under the seabed accessed via a rig. Each of these methods relies on the principle of multiple barriers (Figure 13), a form of defence in depth.

- Low level wastes (LLW) comprise solids such as paper, plastics, filters and clothing and liquids such as washings or effluent. The practice is to dispose of these wastes as appropriate, subject to tight authorisation set by independent bodies. Alternatives include simple underground disposal, engineered trenches for surface disposal or sea dumping (now suspended).

Wastes arising from decontamination and decommissioning of surplus nuclear facilities (eg fuel cycle plant, nuclear power plant and research facilities) will generally require treatment as LLW or ILW, including alpha-bearing wastes.

Completely satisfactory techniques have been developed for the conditioning of HLW, ILW and LLW initially for storage and finally for disposal. Different countries are adopting rather different strategies for managing their wastes (19) but the fact that there are several 'right' ways of tackling each waste management task is a sign of technical strength, not uncertainty. Indeed the expert sees the management of nuclear waste not in terms of a problem needing a technical solution, as the public often do, but in terms of a choice between a variety of technically valid options. Unfortunately the choice of action is becoming severely limited by socio-political pressures stemming from the intense public concern about the subject. An example of this is the suspension of sea disposal. The NIMBY (Not In My Back

Yard) syndrome is, however, dominant, as seen recently over NIREX's proposed shallow waste disposal sites. Even governments indulge in a limited form of NIMBY by requiring nuclear waste to be returned to the country of origin.

Clearly solutions to these difficulties are needed but any technically suitable solution must also be acceptable to public and political opinion.

RISK COMPARISON

All energy technologies carry safety and environmental risks. For nuclear power comparison with base-load coal-fired generation is the most appropriate. The pioneering work of Inhaber in Canada (20), though criticised (eg 21), has been followed by a number of papers comparing the health and environmental hazards of different energy technologies, particularly coal and nuclear. In the UK the papers prepared by the Health and Safety Executive (22,23) and Fergusson (17) at the University of Newcastle are particularly thorough. Reference fuel cycles have been established standardised on the production of 1 GW of electricity. Each cycle covered the activities of fuel extraction, processing, transport, power generation and waste disposal. The first HSE paper (22) considered only the question of occupational accidents and the results (Table 2) do not include the risk to the general public from reactor accidents.

The second of the HSE papers, by Cohen and Pritchard (23), reviewed the literature in the area. They covered both occupational and general public hazards and evaluated both accident and disease (radiological and non-radiological) aspects for the comparative fuel cycles. Their conclusions, endorsed by the HSE, were that,

> "suitably sited, constructed and maintained nuclear systems of the types reviewed involve no more and probably less risk than oil or coal burning systems taking into account in each case the whole fuel cycle. We doubt if further comparative studies would greatly refine this conclusion".

This conclusion is confirmed by Fergusson's work (17) which tried to quantify human health effects attributable to the production of electricity for public supply from coal, oil and nuclear in the UK's generating system. Table 3 shows that the health damage to the individual from coal, oil or nuclear is extremely small when the technologies are well controlled.

Hamilton (24) drew similar conclusions from a study relating to the USA population, siting and technologies. For nuclear power a major contributor to the overall risk is the mining of uranium; Hamilton and others confirm that the contribution to the overall risks from even the worst conceivable reactor accident is very small and attributable to low radiation doses over a large population. Lord (then Sir) Walter Marshall (25) has shown that the consequences of even this unlikely accident can reasonably be compared to the risk the exposed population would run if they each smoked 1/20 of a cigarette a week over the ensuing time period. For the UK population the risk associated with radiation from Chernobyl is equivalent to spending 3 weeks' holiday in Cornwall where the natural background radiation is slightly higher than the UK average (14).

PUBLIC ATTITUDES

Despite the reassuring picture from the risk comparisons quoted above, there are many people who do not view nuclear power as safe. This difference in perception between those with an informed viewpoint, in particular the nuclear industry and the statutory safety bodies on the one hand, and many sections of the public on the other is a major obstacle for the nuclear industry: it has already limited progress and could increasingly do so.

There are many reasons for this public concern ranging from association with nuclear weapons via the sometimes justified distrust of experts to the way even the most minor incidents at nuclear installations are treated by the media. There is continuing concern over the transport and reprocessing of spent fuel with well-publicised leaks at Sellafield impacting on public attitudes even outside the UK. Naturally enough, there is concern over reactor safety after Chernobyl.

Contrary to the impression given and encouraged by critics of the nuclear industry there is a substantial body of opinion in favour of nuclear power.

Prior to Chernobyl this was the majority view in the UK. Not surprisingly, in the immediate aftermath of Chernobyl, opinion was more sharply focussed (fewer 'don't knows') and heavily weighted against nuclear power. However, opinion in favour of nuclear power has subsequently recovered so that today pro - and anti-views are evenly balanced (Table 4).

Politicians in democracies are aware of, and influenced by, public attitudes and nuclear power has become a controversial subject in many countries. In Austria, for example, a referendum decision has halted that country's nuclear plans for the foreseeable future; post-Chernobyl the completed but unused Zwentendorf reactor is to be dismantled. In Sweden the nuclear question became so political that it caused the downfall of two governments, the Social Democrats in 1976 and a Centre Party-led coalition in 1978. In March 1981 a national referendum was held and a policy calling for the phasing out of all nuclear power in Sweden by 2010 won a majority - and that in a country which in 1986 obtained half its electricity from nuclear power. Post-Chernobyl, nuclear power has faced further political pressures especially in those countries affected by the radioactive fallout. Sweden will make an earlier start on the phase-out of nuclear power, though sticking to the 2010 close-down date. Finland has postponed to the mid-1990s a decision on a fifth reactor. Major opposition parties in the UK and West Germany have adopted anti-nuclear policies, while the future of nuclear power in Italy remains uncertain.

Certainly not all is gloom; the Russians have re-affirmed their faith in nuclear power though no new RBMK orders will be placed (15) and there remain strong nuclear programmes in countries such as France and Japan. Worldwide, five planned PWRs including Sizewell B have been coverted into firm orders since the Chernobyl accident. Yet nuclear power is controversial and the influence of public and political

opinion on nuclear programmes is strong.

Clearly the nuclear industry has failed to get its message over. Put simply this message is:

- nuclear power is essential: we cannot do without this energy source;
- nuclear power is at least as safe as other ways of providing electricity;
- nuclear power offers environmental advantages;
- nuclear power provides economic and hence employment benefits.

Getting this message over to the public is now of paramount importance. This is now recognised but we must also recognise that the traditional methods based on information campaigns have not always been fully successful. The industry has not on the whole been prepared to research its information campaigns properly and to use the information media successfully. It is a sad commentary when "The Economist" in making the case for nuclear power (27) writes, "It is not enough to leave the PR campaigning to the nuclear industry, which is outstandingly bad at putting its case". If we in the nuclear industry are to regain the trust and credibility we have lost, then we must be more humble, listen more and address ourselves to people's real worries. To quote Dr Tom Margerison, head of the British Nuclear Electricity Information Group (28), "We have to sweep away the impression of secrecy and develop a feeling of openness and honesty; a willingness to listen; to accept the genuine concerns of the individual; to respond to criticism without arrogance or deviousness; to regard the environmental activist as a useful watchdog rather than an outrageous nuisance".

A fairly recent innovation has been demonstrations of nuclear safety such as the CEGB's staged rail crash involving a spent fuel flask. The point is to show in a way that people can understand that our safety claims are true. Such demonstrations go beyond that which is scientifically necessary in the hope of allaying people's fears.

Almost from its inceptions the nuclear industry has

maintained and encouraged the image that all operations are "fail safe" and that somehow the nuclear industry is "different" in this respect from other industries. Lord Hinton epitomised this attitude when he said that "engineers have always learned by their mistakes; the nuclear industry cannot afford that luxury". This attitude will not do; it lacks credibility. The industry is not "fail safe" in any absolute sense as shown by, for example, the Sellafield leaks, Three Mile Island and Chernobyl. Human error has been seen as a major contributor to things going wrong. The perfectionist "fail safe" attitude merely gives an impression of arrogance or, perhaps worse, complacency.

So what is the truth? Our safety depends on defence in depth, as I have sought to show. We can make mistakes, there is no pretence we know everything, we could be more responsible and we could make improvements. Surely relying on several lines of defence is a perfectly reasonable position. In this sense we are not unlike any other industry.

We also have to address the NIMBY syndrome. Admittedly we are not alone in this; NIMBY applies to non-nuclear development of many types from the route for new motorways and the siting of new airports to conventional refuse disposal sites. However, there are important differences. Media coverage is different for nuclear installations and there are no national lobby groups against the other developments.

In seeking a solution we have to recognise that the public attitude is not always ideological but strongly motivated by self-interest. Whereas the benefits of a nuclear power station or a radioactive waste disposal site are broadly distributed to the nation as a whole, the social costs and risk are carried by a small localised minority. In dealing with public attitudes it is important to distinguish between ideological and self-interest objections.

A number of possible routes forward have been suggested. For example, people living near new motorways can receive compensation for the reduction in the values of their houses; in France electricity consumers living near nuclear power stations were at one time given a discount on their

electricity bills. There is a need to give people some assurance about the low level of risks that occur. Providing environmental and health monitoring could be one way. The provision of objective information and advice, coupled with carrying out the necessary R&D to support that advice, should also help.

CONCLUSIONS

As I have argued in this paper, I firmly believe the world cannot manage without nuclear power. The price to be paid for doing without it is simply too great. This means we must continue our efforts to exploit it safely and to reassure the public about its safety. We also need to ensure that we can exploit the full potential of the Fast Reactor which extends the resource base into the far future when fossil fuel resources will be severely depleted.

We must accept that there are many people who do not see it like this; their perception of nuclear power is one of unacceptable risks. The nuclear industry must take much of the blame for this. We therefore face the task of winning back and retaining the widespread public acceptance of nuclear power. This means being frank both with ourselves and with the public over the safety of our industry, worldwide; and it means tackling the difficult issues of acceptability surrounding radioactive waste management. While there is a clear and continuing need for managerial and technical excellence, that is not enought; the case for nuclear power and the safety of nuclear power must be honestly presented in a way the general public understand.

REFERENCES

1. World Survey: Chernobyl has less than expected impact in orders and future plans. R. Masters, Nuclear Engineering International, June 1987.

2. World Nuclear Industry Handbook, 1987. Supplement to Nov 1986 issue of Nuclear Engineering International.

3. Nuclear Energy and its fuel cycle; prospects to 2025. NEA and IAEA, OECD, Paris, 1986.

4. Generating the world's electricity. Shell Briefing Service, No. 4, 1986.

5. The future of nuclear energy. D.A. Davis, at IEE Conf "Energy Options", Reading, 1987.

6. Nuclear Stays Competitive. PMS Jones, Nuclear Engineering International, June 1986.

7. Future global warming from atmospheric trace gases. R E Dickinson and R J Cicerone, Nature, Vol 319, 9 Jan 1986.

8. Emissions data for nitrogen oxides and hydrocarbons. A Eliassen and J Saltbones, Norwegian Meteorological Institute, Oslo, Norway, 1987.

9. Public or private electricity - the American experience. A report from the Fact-Finding Team from the Electrical Power Engineers Association, July 1986.

10. B P Statistical review of world energy, 1986.

11. The Soviet Union and the development of nuclear power - an overview of plans and the Chernobyl accident. A Petrosyants, IAEA Bulletin, Autumn 1986.

12. The accident at the Chernobyl nuclear power plant and its consequences; information compiled for the IAEA Experts' Meeting (draft), post-accident review meeting, 25-29 August 1986, IAEA Vienna. USSR State Committee on the Utilisation of Atomic Energy (Extract published in Energia Nucleare, Sept 1986).

13. The Chernobyl accident and its consequences. J. Gittus et al, UKAEA, London, March 1987.

14. The Chernobyl accident and its consequences. J Gittus in Atom, June 1987.

15. Soviet nuclear power after Chernobyl. V Legasov, Nuclear Engineering International, June 1987.

16. Sizewell B Public Inquiry - Report by Sir Frank Layfield, Vol II, HMSO, London 1987.

17. Comparative risks of electricity generating fuel systems in the UK. RAD Fergusson, Peter Peregrinus Ltd, 1981.

18. The next steps in nuclear waste disposal. Address given to the Parliamentary and Scientific Committee. L. Roberts, Science in Parliament, Vol 43, No 183, March 1986.

19. Radioactive waste management: a status report. IAEA, Vienna, 1985.

20. Risks of Energy Production. H. Inhaber, Atomic Energy Control Board, AECB 1119/REV 1, May 1978.

21. Risks of renewable energy sources; a critique of the Inhaber report. J P Holdren et al, ERG 79-3, Energy and Resources Group, Univ Calif, Berkeley, June 1979.

22. Report by the Health and Safety Commission on the hazards of conventional sources of energy. HSE, 1978.

23. Comparative risks of electricity production systems; a critical survey of the literature. A V Cohen and D K Pritchard, Research Paper 11, HSE, 1980.

24. Health and environmental hazards of different energy systems. L D Hamilton, IAEA, IAEA-CN-42/504, 1983.

25. Big Nuclear Accidents. Sir Walter Marshall, Paper IAEA-CN-42/18 presented at IAEA International Conf on Nuclear Power Experience, Vienna, Sept 1982.

26. World Survey; Country-by-country progress review - non Comecon. Nuclear Engineering International, June 1987.

27. Nuclear's charm, The Economist, March 29 1986.

28. Treating the anti-nuclear allergy in Britain. R Masters interviewing Dr Tom Margerison in Nuclear Engineering International, Oct 1986.

Table 1 - Some Major Disasters

Event	Number Killed
Nurek Hydroelectric Dam, USSR, 1987	19
Flixborough, 1974	28
Chernobyl (short term only), 1986	31
Sinking of Herald of Free Enterprise, 1987	188
Road Tanker Explosion, San Carlos, Spain, 1978	200
Big Air Disaster, typically	2-300
LPG Explosion and Fire, R.Nile, 1983	317
LPG Explosion, Mexico City, 1984	500
Landslip into Vajont Dam, Italy, 1963	2000
Bhophal (short term only), 1984	2600
Chernobyl - long term	several thousand?

TABLE 2 - OCCUPATIONAL ACCIDENTS

Estimated number of deaths due to accidents per GWe year of electrical energy sent out.

Deaths/GWe year

Coal	Extraction	1.4
	Transport	0.2
	Generation	0.2
		1.8
Nuclear	Extraction (USA)	0.1
	Transport	Insignificant
	Generation & reprocessing	0.15
		0.25

TABLE 3 - TOTAL RISKS OF POWER GENERATION

Risks associated with different forms of electrical power generation in the United Kingdom: Deaths/GWe year.

	Occupational		Public	
	Accidents	Disease	Accidents	Disease
Coal	0.5–2.5	0–3	0–0.3	0–0.7
Oil	0.2–1.2	–	$1\times10^{-5} - 4\times10^{-3}$	0–0.7
Nuclear* (AGR)	0.1–0.8	0.05–0.3	9×10^{-4}	0.01–0.1

* Includes fuel extraction though for the UK extraction is carried out overseas

Table 4 UK Opinion Surveys

	In Favour	Opposed	Don't know
Early April 1986	47	37	19
Late April 1986	37	53	10
December 1986	42	42	16
March 1987	46	40	14
June 1987	44	42	12

(Source: NEIG)

Early history

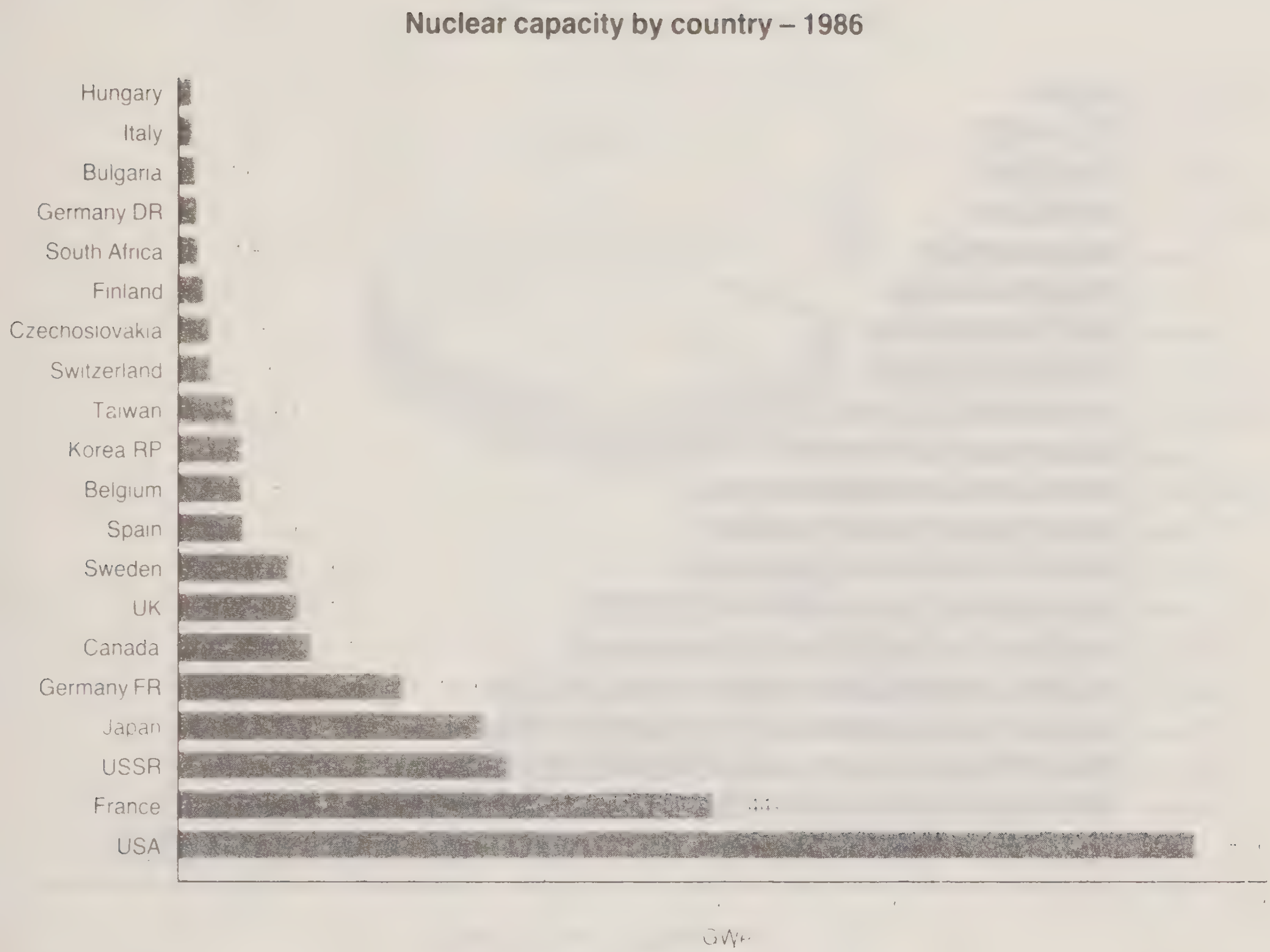
Experimental reactors

Year	Reactor	Location	Type
1942	Enrico Fermi	Chicago	Thermal
1951	EBR1	Argonne National Laboratory, USA	Fast Reactor

Power reactors

Year	Reactor	Location	Type	Power, MWe
1954	Obninsk	USSR	Graphite moderated, water cooled	5
1956	Calder Hall	UK	Magnox	4 × 50
1957	Shippingport	Pennsylvania	PWR	60
1959	Marcoule	France	Magnox	40

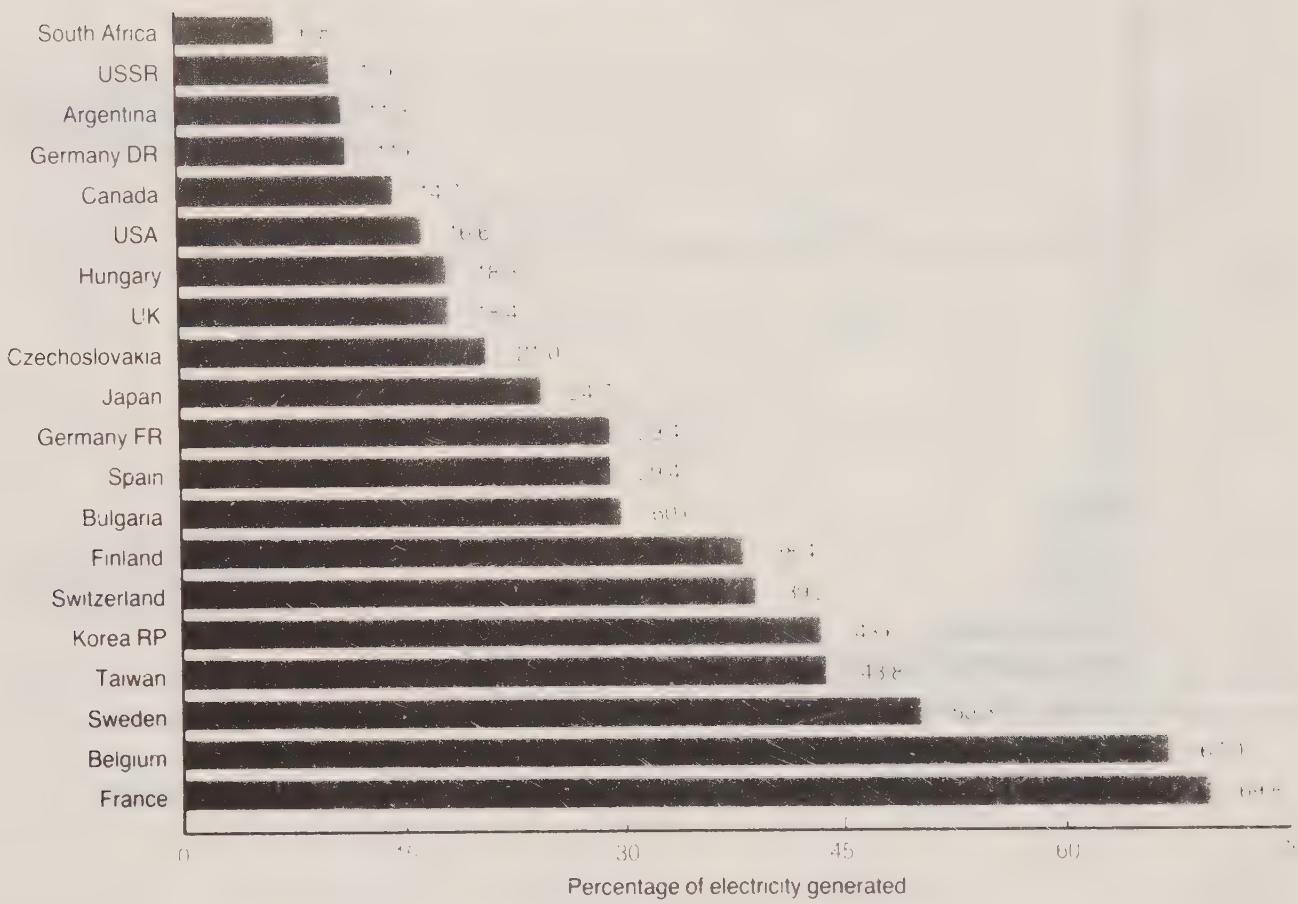
Figure 1



Leading 20 countries
Data for 1986
Source: Ref

Figure 2

Nuclear share of generation in 1986

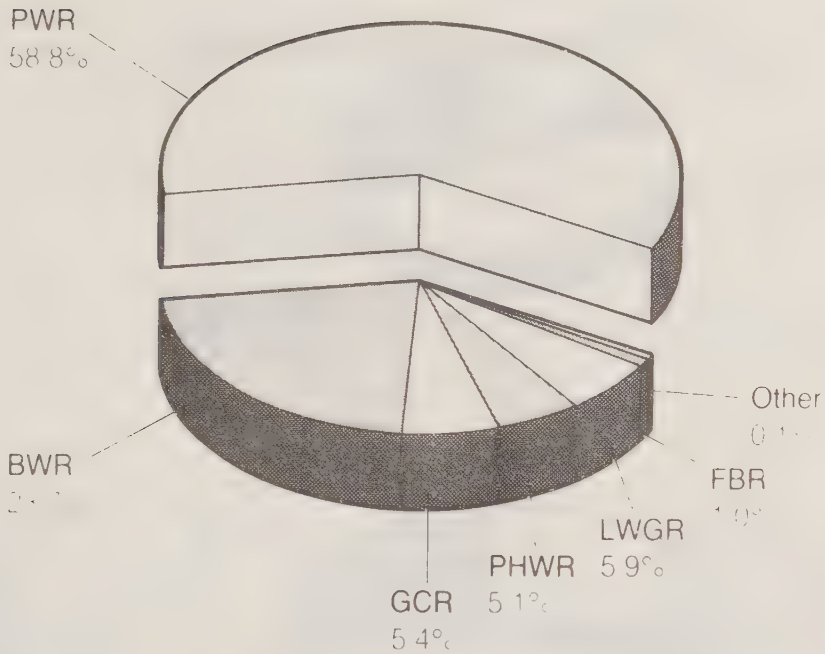


Leading 20 countries
Data for 1986
Source *Ref 1*

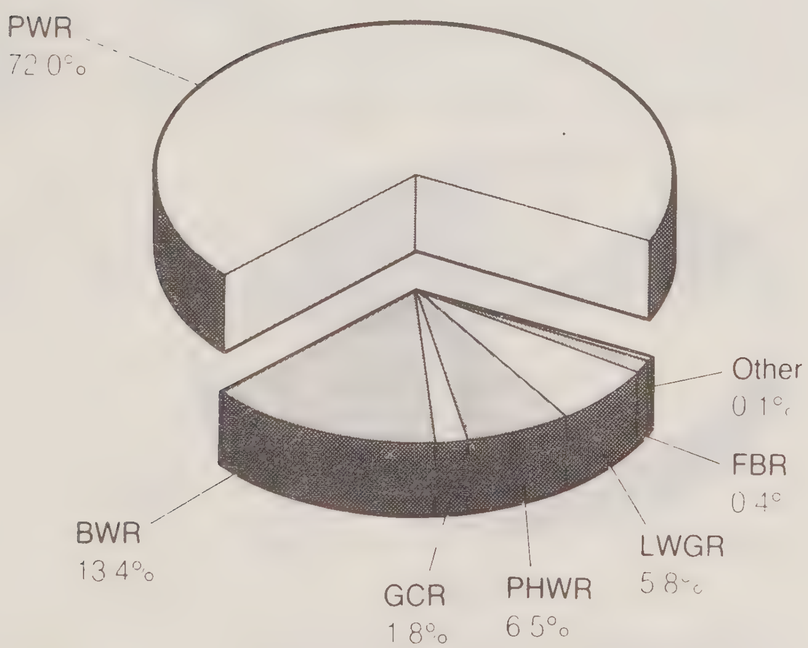
Figure 3

The World's reactors

In operation



Under construction

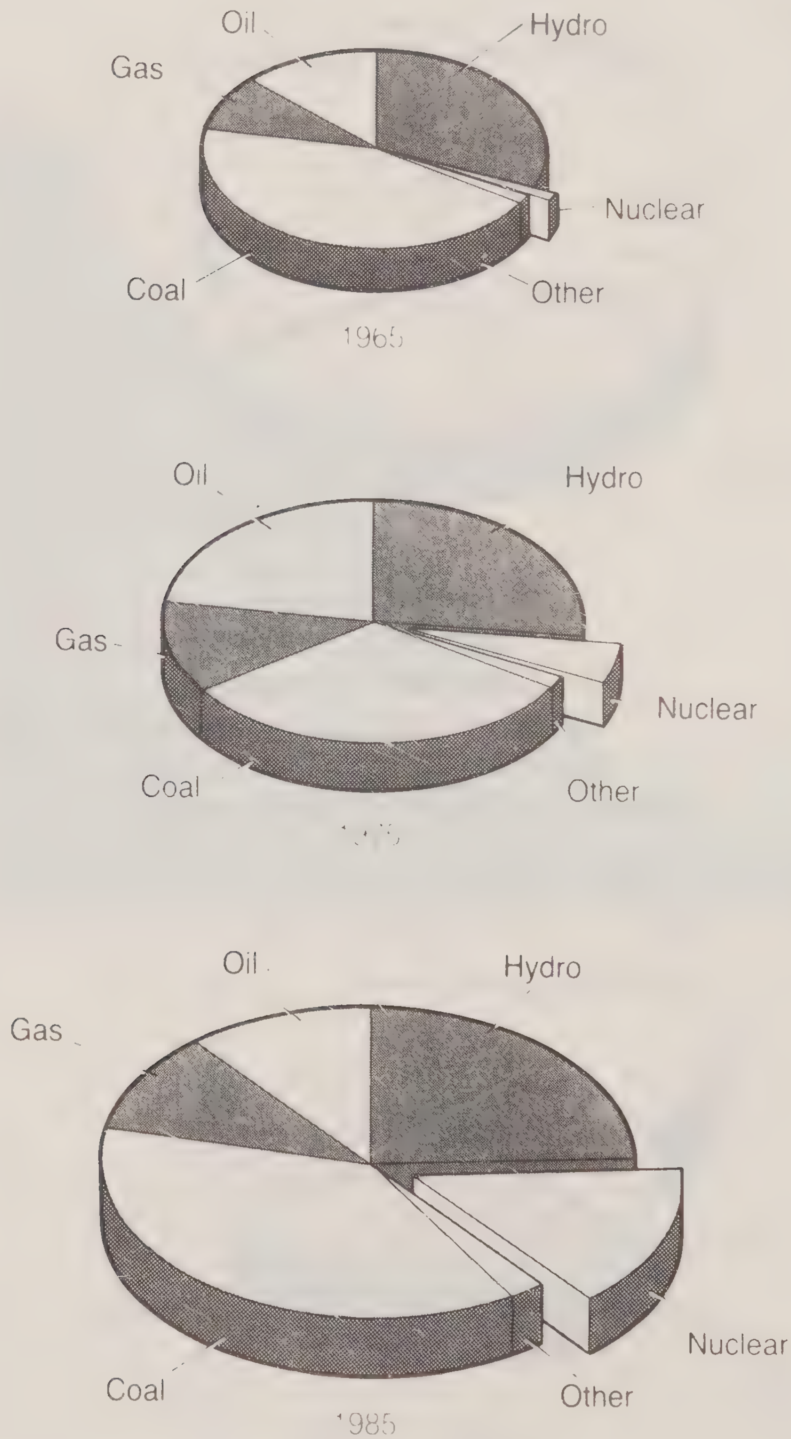


Data is for May 1986
Source: *Ref 1*

Figure 4

Primary energy for electricity generation

Western world* 1965-85

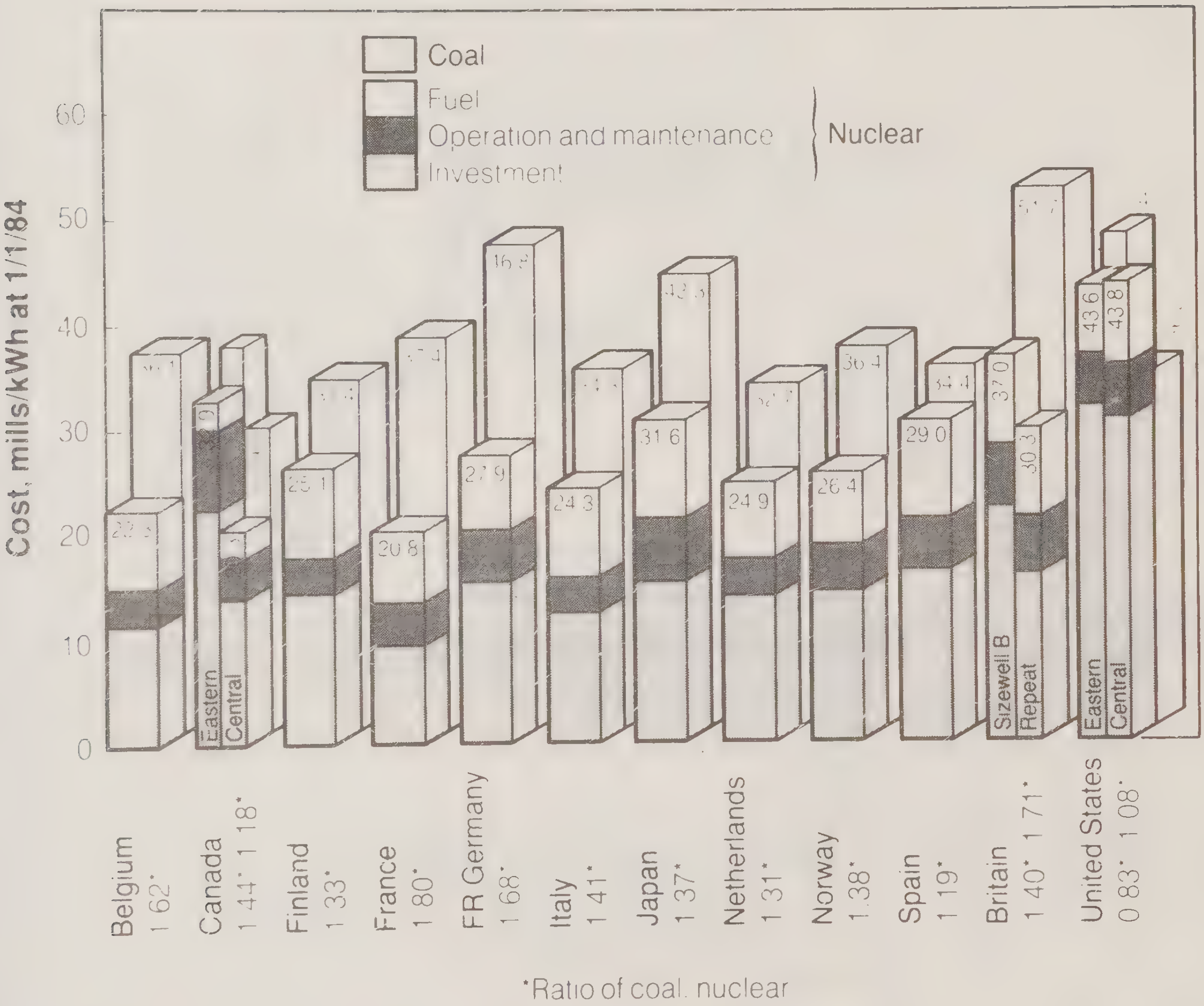


*Excludes USSR, Eastern Europe and China

Source: *Ref 3*

Figure 5

Generation cost comparison

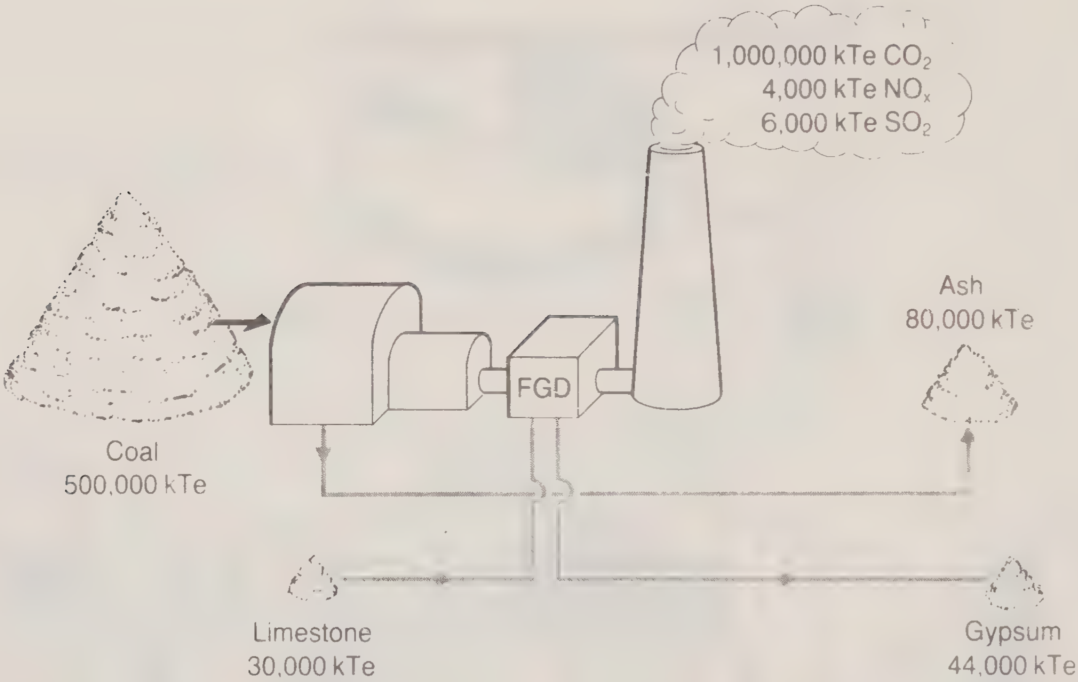


Source: *Ref 6*

Figure 6

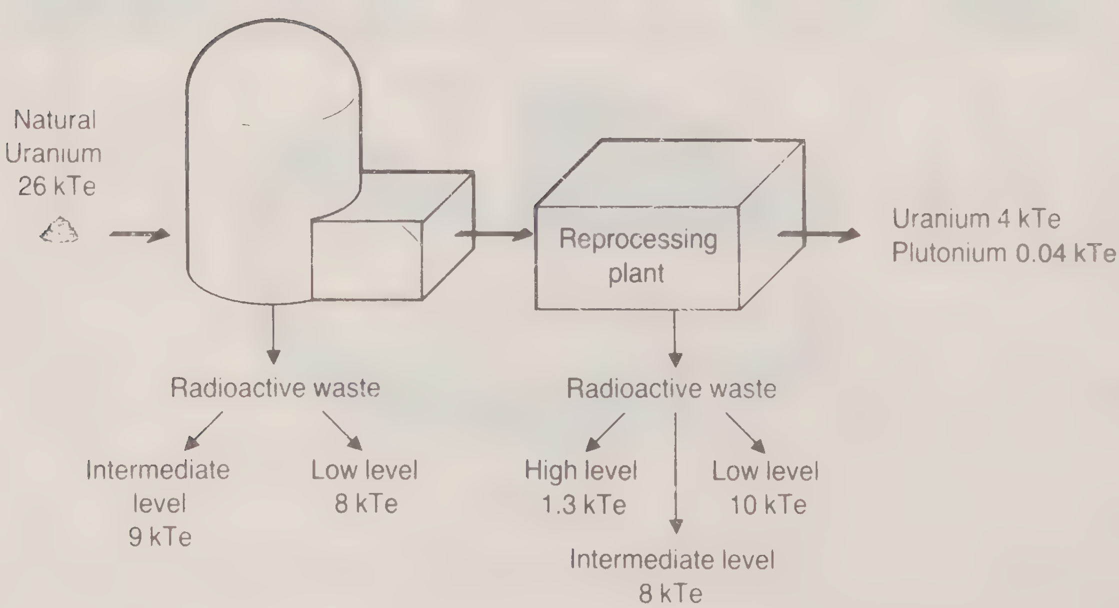
1986 Nuclear electricity share as generated from coal

(coal station with limestone gypsum flue gas desulphurisation)



1986 Nuclear electricity share as generated from uranium

(PWR station with spent fuel reprocessing)



Note: Based on Ref. 5

Figure 7

Worldwide reactor orders
(Net of cancellations)

Source: *Kidder, Peabody & Co*

Figure 8

World primary energy demand
1900-1986

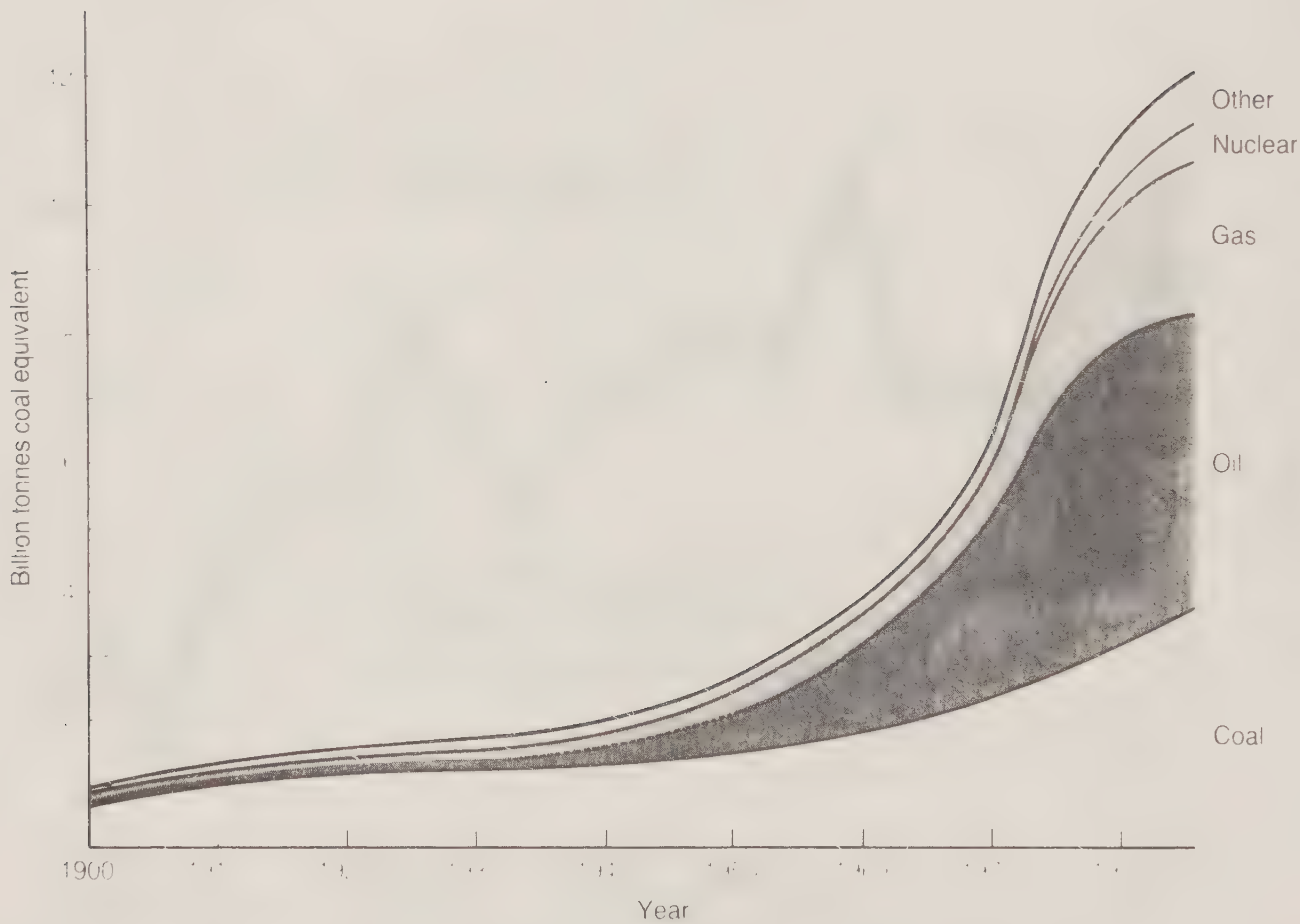
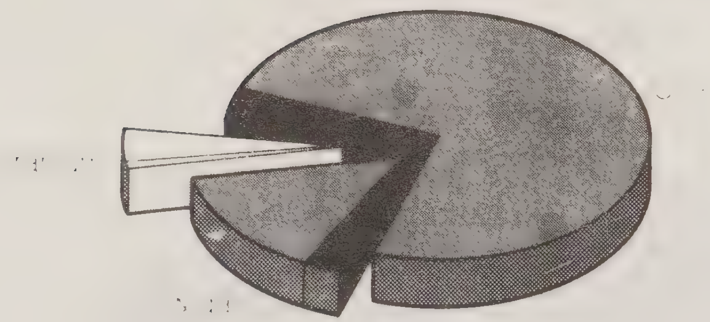


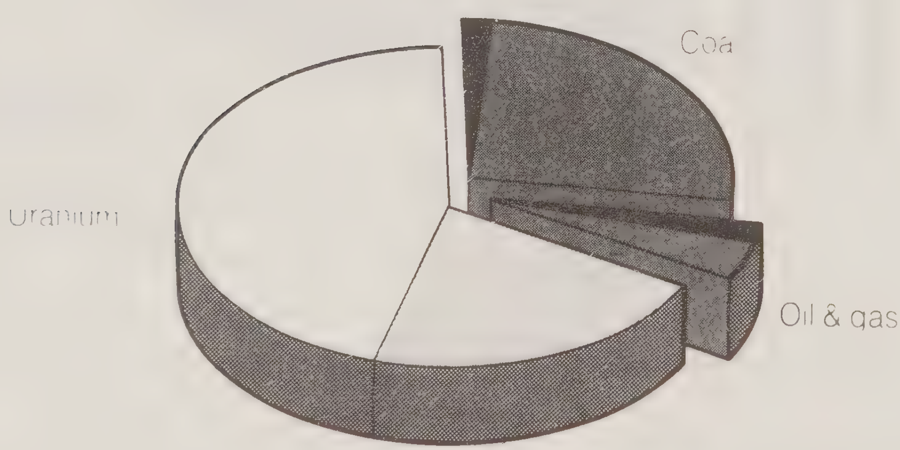
Figure 9

World fuel resources

Uranium used in thermal reactors only



Uranium used in thermal and fast reactors



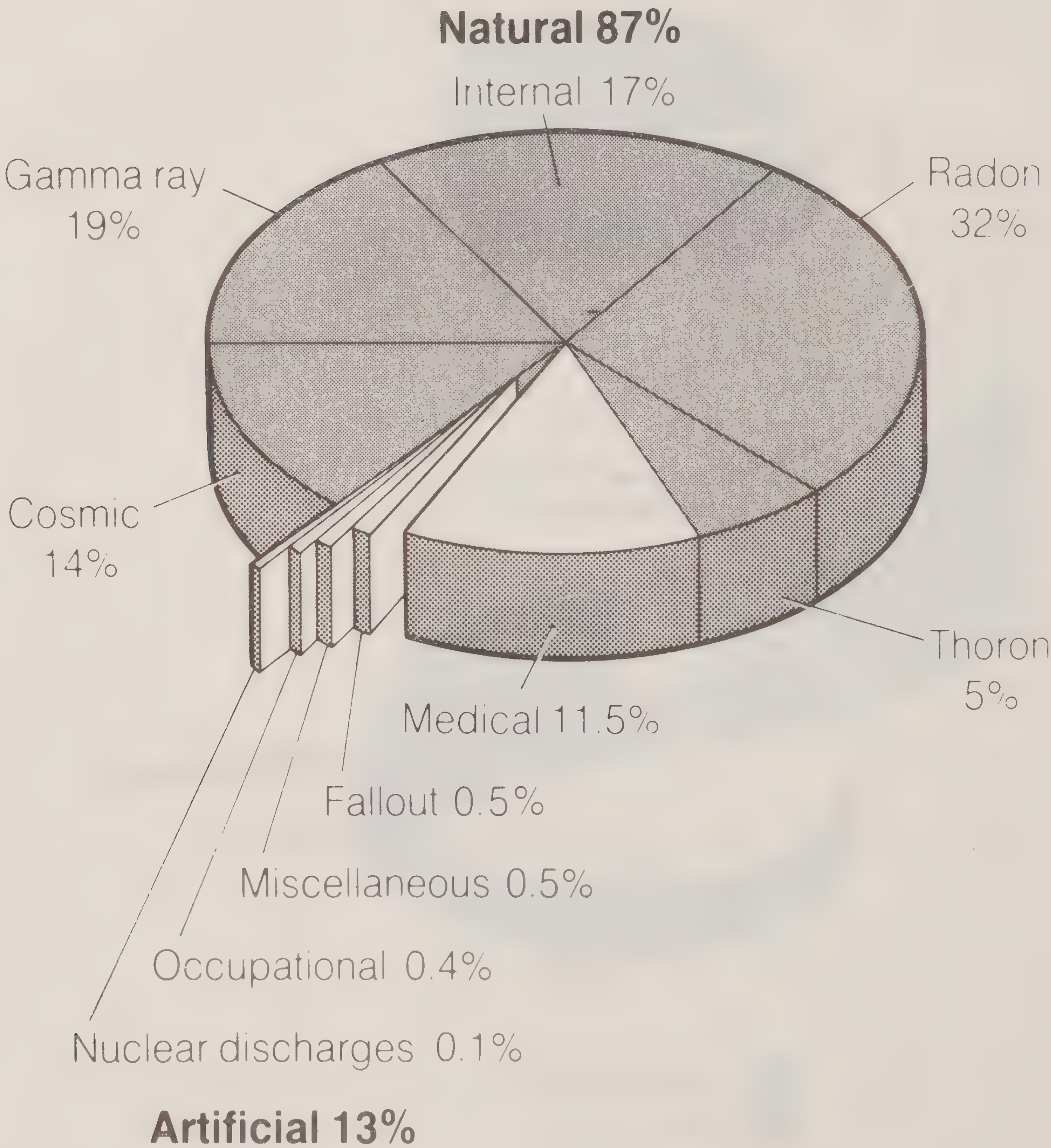
Fossil: Proved recoverable; Additional

Uranium: Reasonably assured and estimated additional; Speculative

Sources: *WEC 1980, OECD, IAEA*

Figure 10

Composition of total radiation exposure of UK population



Source: *National Radiological Protection Board*

Figure 11

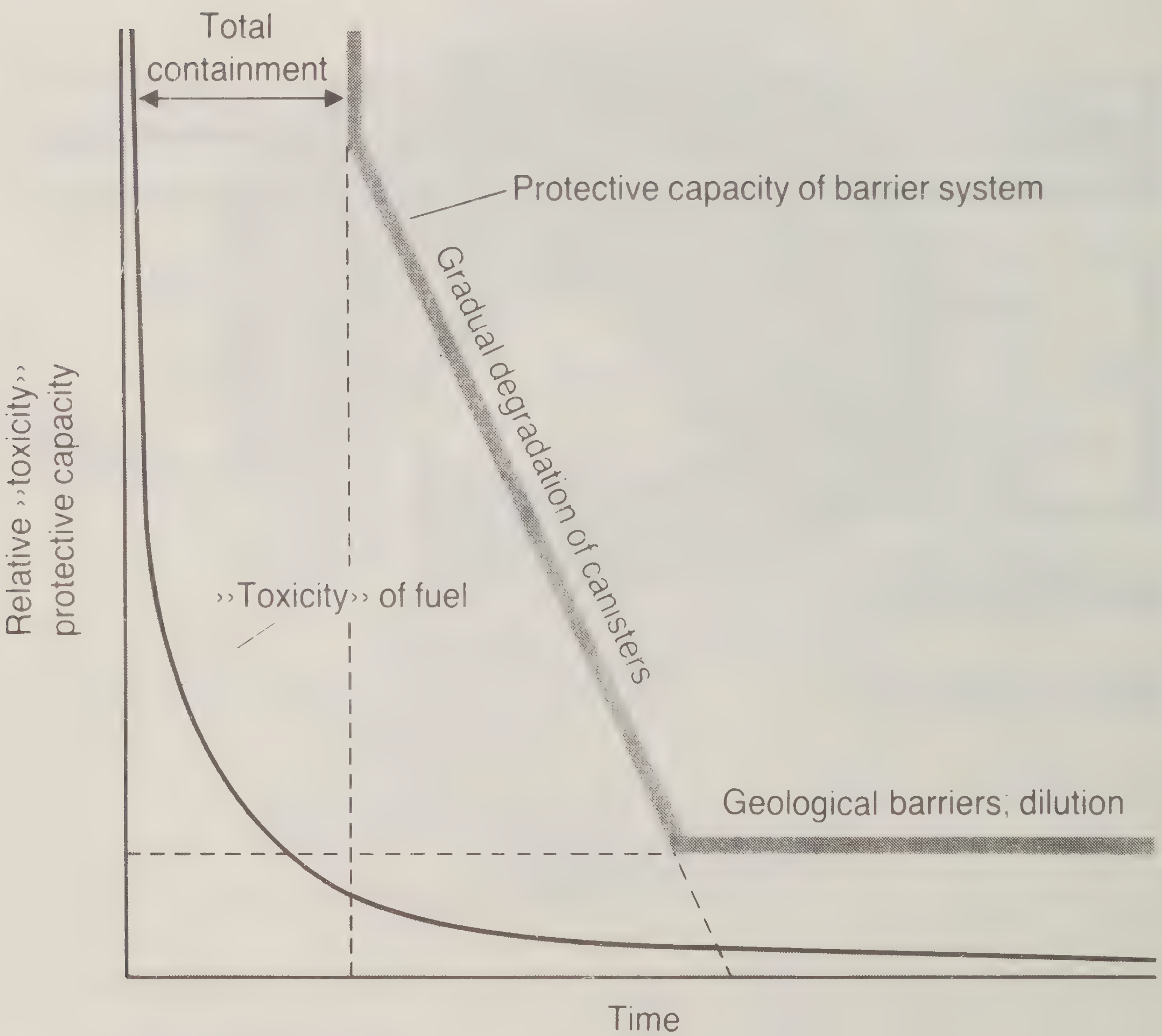
Waste quantities are small – a great help

Waste	Waste arisings in UK Approximate annual volumes Cu m	% of total radioactivity
HLW – from reprocessing	100	95
ILW	7,500	5
LLW – large volumes of very low activity	25,000	Less than .001
INDUSTRIAL WASTE		
Toxic Chemical Waste	4,000,000	

Source *Ref. 16*

Figure 12

Schematic function of the barrier system



Source: *Swedish Nuclear Fuel Supply Co.*

Figure 13

nsca

54th ANNUAL CONFERENCE
26 - 29 OCTOBER 1987
BRIGHTON

CIVIL NUCLEAR POWER IN THE UK
The Case Against a Continuing UK Programme

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Let me start by saying straight out that I'm not going to preach against nuclear power as a matter of doctrine to you but what I want to do in putting my case is to suggest that there has been a thoroughly unbalanced emphasis by successive governments on nuclear power at the expense of other, perhaps more important, energy technologies and particularly technologies which can help at the use end, at the demand end of the energy cycle. When you look at the simply colossal public expenditures there have been on research and development, for example the fast breeder reactor on which Mr. Collyer was speaking this morning, - it is estimated by the House of Commons Energy Committee to require the total expenditure of approaching £6 billion in R & D before it is even at a point where it could begin to produce electricity - you will see the sort of sums we are talking about. When you consider the remarkable levels of capital expenditure, the staggering cost overruns on most major new power stations that the Generating Board has been involved in and when you look at the intellectual capital, the commitment of scientists and of intellectual energy in the nuclear direction, you will, I think, understand, if not agree with, my argument that there has been imbalance in thinking about it.

So I want to show that, in present circumstances, we would do better to move away from nuclear power progressively rather then embarking on major new programmes. In arguing that, of course, I shall be addressing a number of the claims made by Mr. Collyer this morning in his very interesting address, some of which I do disagree with quite strongly.

I would like to start if I may at the international level and then, against that background, look at some specific questions concerning nuclear power in Britain, particularly economic questions. Now Mr. Collyer has focussed a great deal on the world scene and he advanced a conventional picture of the way that world energy requirements are likely

to develop over the next thirty or forty years - a doubling or trebling of world energy requirements as the developing world comes to require energy at approaching the same sort of intensity of use as the industrialised world. With that view, which is very widely held and he showed us some graphs of it, goes the view that we face potentially, the world community faces, very stark trade-offs at some stage between global security of energy supplies, between having enough energy, and enviromental considerations. I would agree that there is no doubt that the world faces, into the next century, some horrendous problems as world population doubles over the next thirty years but I believe that the people who characterise energy requirements in the way I have just described underestimate very considerably the intensity and seriousness of the political, social and environmental problems to which this sort of expansionist approach in the energy sector would give rise. Whichever way you look - whether you look at greatly increased coal use, which will carry with it environmental acidification of soil and air, as we have been discussing today; potentially, with CO_2 increases, global atmospheric warming with possible very serious climatic changes, with the greenhouse effect and severe air pollution in third world countries.

That's coal but similarly, if we look at nuclear power, the prospect of Chernobyl type accidents recurring is a very, very real one. In fact, there's been a very interesting correspondence in recent weeks in "Nature", which suggests for major accident of that scale, a 70% probability of one within the next six years, and certainly within the next decade or so I think one could confidently expect incidents of that kind. And, of course, the problems for the acceptability of nuclear power with several accidents seem to me greatly underestimated by those like Mr. Collyer who argue that these are simply blips that have to be accepted - I do not believe that is realistic.

Equally, if one looks at the potential of the fast breeder reactor, one faces the prospect there, as a requirement of the fast breeder, of massive commercial use of plutonium with all the associated problems of nuclear weapons proliferation. It is no coincidence that the American Government has been very seriously concerned about this

throughout the Seventies and I would argue that that issue, which has hardly surfaced in recent years, will become a very major obstacle to the deployment of fast breeder reactors in the way that Mr. Collyer was suggesting.

So you have problems with coal, you have problems with nuclear, you have problems with oil - increased oil use, pressure on prices, the sort of global social and political instability that will produce - and equally, I am not going to claim that renewables do not have their own environmental problems and indeed there is probably fairly limited scope for them within the next twenty years.

So the global energy priority I want to underline is how do we provide energy for what a growing world population will need without seriously aggravating global environmental and security problems. And I put to you that that way of characterising the challenge that is ahead for policy makers all over the world in this broader social and environmental context leads to a quite different picture of what is a realistic scenario for the way that energy development should be conducted into the next century.

All of these issues I have been outlining are central themes in a report which was published earlier this year - The World Commission on Environment and Development, the Brundtland Commission, its report "Our Common Future". This is a committee set up by the United Nations in 1983, chaired by the Prime Minister of Norway, with a number of statesmen and experts on it from all over the world, developed and developing world. The essence of this Report is to recognise the interdependence from now on of global environmental health and future global economic well being. It highlights the accumulating environmental degradation and the economic consequences that it carries with it, whether we are talking about deforestation in third world countries, desertification of the kind that we have seen in Africa, famine, massive pollution problems. The Brundtland Commission, which I emphasise is a highly prestigious and really unprecedented Commission, has concluded that the way forward for world economic growth, if we are to have world economic growth in a sensible way, is to radically strengthen environmental policies and perspectives for the sake of the

world's economy, both rich and poor nations alike. I do stress it comes up with a number of very significant and far reaching proposals and the most relevant today is that this essentially economic Report underlines that realistically, for reasons of global security, we need shifts in the emphasis of national energy policies to achieve balances which are both environmentally and socially sustainable. In the Commission's view this means that the emphasis of energy policy will have to turn towards energy efficiency coupled to more research and development of renewable energies rather than continuing the emphasis, particularly since the War, but since the Industrial Revolution for that matter, of ever expanding energy supplies, having institutions simply geared to ever expanding energy supplies - and, of course, our institutions in Britain clasically are geared to precisely that, as I shall argue in a minute. This will entail, say the Brundtland Commission, profound structural changes in national socio-economic and institutional arrangements - now that's sort of United Nations speak for big adjustments to the way in which our energy institutions - in British terms the CEGB, the Electricity Council, the Gas Corporation and so forth - to reduce the emphasis on supply and move towards the demand end of the cycle. That is the verdict of the most important international analysis linking world economic priorities and environmental prospects which has ever been published.

So what does this mean in energy terms, how does it relate to what we are talking about today? Let me give you a taste. It just happens that a new international study is just about to be published by the World Resources Institute in Washington and I have seen a draft of this. It is a collaboration between experts from Brazil, the United States, Sweden and India and it is a very detailed analysis. This is a rather imposing table but the green bits show the share of energy use of developing countries, the red bits show the industrialised countries. In 1980 total global energy use, the industrialised countries using a great deal more than the third world, although our population is only 1.1 billion and the third world, the developing countries 3.3 billion. What that means is that we are using six times more energy than they are per capita.

So how does the future look? We move to the year 2020. Here's the World Energy Conference, again the most prestigious orthodox collection of national energy specialists. In 1973 it produced two scenarios for energy development up to the year 2020, rather like the figures that Mr. Collyer was showing. Here's the low growth scenario, here's the high growth one. Let's notice some things. Where is all the growth in energy consumption coming from? Industrialised countries. The per capita use that they are projecting in industralised countries is not going down as Mr. Collyer said, it's going up - from 6 kilowats per head, 8 or 9 on the high scenario. The third world still, relatively speaking, a small proportion of the global requirement and not very great increases in per capita consumption. The study I am telling you about now goes under the heading of Energy for a Sustainable World and it argues that it is possible that we could have something like this in 2020 instead. That requires the industrialised world to use its own energy more efficiently and in so doing to reduce the amount of users and the third world marginal increases in intensity of energy use but not anything like on that scale. Now I just emphasise that, particularly this bit, what could happen in industrialised countries over the next thirty years, is based by these analysts on very detailed examination of actual practice in the United States and Sweden and it takes into account the energy implications of structural changes in those economies that are already going on. It looks at the opportunities for introducing cost effective, more efficient in-use technologies at the normal rates of capital equipment turnover and growth, for example in areas like space heating, lighting, transport, manufacturing and industrial motors; and what it implies is, in personal terms, that in the year 2020 you and I could be using half the energy that we are using now individually. Now that is not that great when you look at the developments of in-use technologies that are going on if they are given the right push by governments.

What would that mean, that scenario, if it was followed in terms of actually using fuels? Well this is the picture they come up with. First of all, in these middle ones, this is where we are now, you see very heavy emphasis on coal and oil and a relatively small amount of nuclear - we are talking about global. In 2020 an enormous amount of fossil fuels

being consumed, substantially larger and a very big block of nuclear. An even higher scenario from another expert institute in Vienna - bigger nuclear blocks. But with this other scenario it becomes possible to minimise some of these global environmental problems and reduce oil consumption, reduce coal consumption, some increases in gas consumption and really very minor increments in nuclear power.

The key factor to all of this is the concentration on enormous increases in energy efficiency, particularly in the industrialised countries. Now most of the energy efficiency improvements that they are talking about - as I say heating, lighting, manufacturing processes, industrial processes and so on - if introduced, if stimulated by governments they argue could actually create simultaneous improvements in many other factors of production, whether labour, capital or materials as well as energy. So it is a high-tech, high-growth future that this is intended to embrace. And they also contend that the steps that are required to get there, for an industrialised country like ours, they are not qualitatively great leaps but once goverments have accepted that that is where we need to go, they involve things like eliminating energy subsidies, direct and indirect, and that is not insignificant, as I'm sure the CEGB would confirm; major increases in public expenditure to increase conservation and energy efficiency at the end uses rather than on supply; changes to the duties of our utilities and energy suppliers to require them to be more efficient; eliminating the institutional biases which you find everywhere in the energy economy in favour of expanding supply. I stress this is just the sort of approach for which the Brundtland Commission is calling, for profoundly important reasons to do with the health of the world economy as much as to do with the global environmental problems we face. What I am saying is that expansion of new energy supply, contrary to what Mr. Collyer has said, will increasingly not be the problem and if that is the case then nuclear power becomes a much less significant preoccupation for all of us, I would suggest.

Mr. Collyer implied that there is a necessary link betwen economic growth and energy growth, that as GNP increases we have to increase energy use. That simply is not the case. You can see here between '73 and '84 the American

economy grew by 17% and energy use per capita dropped by 10%. In all OECD countries GNP increased by 18% and energy use per capita dropped by 6%. These dramatic shifts in the United States reflect the workings of a largely market economy, accompanied by some public pressure which led to promotion of energy efficiency by consumers. This is just the tip of an iceberg, this potential increase in efficiency, and I think this is increasingly being recognised. Let me just show you, I can't resist this, some forecasts of American primary energy consumption for the year 2000. Here is the year in which the forecasts were made, starting in '72 going up to '83. Back in '72 the Department of Energy was saying 200 quadrillion btu's per year for the year 2000. An environmentalist who works for Friends of the Earth, Amory Lovins, was saying 125. As time went on, and we went through the 70's and 80's, increasingly everyone starts to adjust downwards so that we now have the Department of Energy in 81/82 projecting a smaller year 2000 consumption than Amory Lovins was in 1972. This is a very significant shift in the most powerful economy in the world.

In this country our performance in the energy efficiency sphere, as the International Energy Agency has repeatedly said, is deplorable and that has a lot to do with the almost exclusive concentration of our public sector utilities, like the CEGB I have to say, because of its statutory obligations on ever increasing supplies. Again and again the House of Commons Energy Committee have asked the Government to examine this question, to confront the need to compare more effectively whether we are spending money in the right direction and and whether we should not be spending a lot more on conservation than on supply and the Government has repeatedly stonewalled.

So Mr. Chairman I submit that all this will have to change, for the reasons I have been articulating, and I hope that it is clear by now from my argument that nuclear power, in the way envisaged before lunch, has a distinctly marginal relevance to this simple issue that we all have to be concerned with, not only nationally but as world citizens. This study I just mentioned will be published shortly, the Royal Institution I understand will be launching it in December and I think that it is going to make a very

important impact.

I have talked then about the international scene. Let me turn briefly to the short term in Britain because not only, in my view, is nuclear not likely to be fundamentally important to the problems that we face at world level, but here at home nuclear power is likely to face a growing challenge as a realistic investment. Fundamentally this is because of economics. I did ask Mr. Collyer a question before lunch about whether nuclear power historically had ever been cheaper than coal and he did say that he thought that this was not absolutely clear cut.

Let me just put some CEGB figures before you which I think do show quite clearly that up to 1985 at Magnox stations 2.6 pence per kilowat hour, coal 2.38 pence per kilowat on a 5% discount rate. That is from the CEGB's own analysis of generating costs in April 1985. Even with the AGR's, Hinckley 2.6 pence per kilowat hour, the first half of Drax, coal fired station, 2.46p. Recently the Chairman of the CEGB on "Brass Tacks" on BBC admitted, like Mr. Collyer, that cheap nuclear power, cheaper than other forms of generation, is jam tomorrow. On the face of it, Sizewell might well be such jam. That again was the implication of what Mr. Collyer said, but there has been a lot of water passed under the bridge since the Sizewell Enquiry, not least a much more realistic assessment of what is going to happen to coal prices over the next twenty years. I won't go into the detail of that, I'll just simply put up a figure that the former Chairman of the National Coal Board put into the House of Lords debate in March 1987. Lord Ezra, calculating on the basis of current, realistic, central expectations for coal prices over the lifetime of Sizewell, argued that PWR 2.83 pence per kilowat hour, coal fired stations 2.66 pence per kilowat hour. In other words that Sizewell B2 would be likely to be more expensive than the most immediately obvious alternative. But the Secretary of State gave the go-ahead on the grounds that, notwithstanding the question of cost, it was still marginally cheaper, in his view, than coal and we have seen that Lord Ezra disagreed, but also that it was needed, that we needed some new capacity to meet future demands. On the basis of this, we are having the CEGB now, and I am sure Frank Jenkins is

going to do it after me, arguing that a stream of PWR investments is going to be necessary over the next decade or so.

In fact they are effectively calling for expenditures of well over £20 billion over the next decade on new nuclear power stations. Should we have confidence in their forecasts of our requirements for new power? This is the electricity industry's forecasting errors between 1973 and 1986. Here are the forecasts that were made in 1967 for the year 1973, i.e. going ahead seven years and there is the reality so you have the gap in each case, 76, 79 and 86. The average forecasting error was 26% and I do not think Frank Jenkins is going to dispute that but in principle forecasting errors of that kind, if they are then used a basis for new investment, can lead to simply colossal misallocation of resources. A single power station these days costs upwards of £1.5 billion. Against that background, I think you have to look at the sort of forecasts that the CEGB is using to justify new power station investment. I have plotted out here the pattern of actual demand that there has been, the mean is sort of around 42 Gigawatts, between 1970 and the current year. Over the last 15 years it has hovered around here and now they are postulating that it is going to go off in this direction. Would you put your money on that? You are being asked to put your money on that and this is precisely the same sort of forecast that was subject to the massive errors I was showing you in previous years. Arguably, perhaps there is a lot of wishful thinking there. Perhaps it is hard to resist the view that these forecasts are normative, that is to say are designed to showing the outcome which the CEGB actually desires as much as objective ones.

Leaving that aside, even assuming that plant is needed, do we need large new nuclear and coal plants? If we assume that those forecasts are a potential, let's say upper limit, is it the case that the alternatives of large nuclear plant or large coal plant are the only available options?. One great merit of the current debate about privatisation requirements of the kind I have just shown you and I have yet to come across an energy economist who believes that a private sector company would make a judgement going for a large nuclear or coal fired capacity in these circumstances.

I will just show you one list of options - I won't go through them in detail - by an economist whose work was treated as an independent test case for the CEGB at the Sizewell enquiry by Sir Frank Layfield and this is Dr. Nigel Evans of Cambridge. Here is his list of generation options - nuclear and coal down here - but look at some of these. A private sector company would seek first to increase conservation and efficiency measures, to extend lives of existing power stations, use mothballed oil fired stations, convert coal stations to oil, build smaller power stations, build gas fired stations, use renewables or bring in more imports from France. Plainly these are short term options that the market would tend to throw up quite apart from these. Obviously some of these are more consistent with the environmental priorities that I was describing at the beginning of this talk. I have marked in blue the ones that I think are the more environmentally benign ones and if one is thinking about trying to reduce fossil fuel use. My only point is that even the immediate options are much more various than the CEGB implies. There is no need to be locked into the CEGB's view of the future and I do quite clearly refute the claim that Mr. Collyer made this morning of obvious economic advantages. I do not believe that can be sustained and that is why Walter Marshall said earlier this week that there would be no more nuclear power in the UK if the CEGB was split up and sold. I don't say there will never be a case for another nuclear reactor - that is not my purpose. What I do say is that far and away the most important priority is to get the energy economy onto a different trajectory and that will be one in which this question of nuclear power and how many massive increases in capacity we are going to need will really play a very small role.

Mr. Chairman I have not talked about safety - I deliberately didn't. I wanted to focus the issues in the sphere where I think the industry wants it focussed which is on economics and world energy security and I would simply leave you looking at that table as the message that I think we have to have most firmly in mind when we think about the future role of nuclear power.

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CIVIL NUCLEAR POWER IN THE UK
The Case For
a Continuing UK Programme

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THE GENERATION OF ELECTRICITY

CEGB plans for building new power stations all derive ultimately from its statutory duty, which is to provide a secure and economic supply of electricity in bulk in England and Wales. In formulating its proposals relating to its function, the CEGB must take into account their effect on the amenities of the countryside.

Plainly, if the statutory duty is to be fulfilled, some impact on the environment is unavoidable. Moreover, the practical constraints on the planner of new generation supplies are severe. Electricity is made by the conversion of primary energy: the main sources of fuel or energy being fossil fuels (coal, oil or gas), uranium, and the so-called renewable resources (hydro, solar energy, wind energy, tidal energy, etc).

Since electricity cannot be stored in bulk, and must be gnerated at the time the demand arises and in sufficient quantity to meet that demand securely, it is not practicable to meet more than a very limited amount of the total demand from renewable energy sources that are intermittent in nature. In the main electricity must be generated from the fossil fuels or from uranium using thermal reactors (uranium) or boilers (fossil fuels) and steam driven turbine generators.

As it is well known, the thermodynamic cycle entails the rejection of the greater part of the primary energy as waste heat (though a limited part of this heat may be recoverable if economic go-generation schemes can be found). Consequently, the CEGB needs to process a very large volume of primary energy indeed.

Some people tend to be upset because so much energy is rejected. But it must be remembered that, as compensation for this, we get a product - electricity - of very high quality, cleanliness and efficiency at end of use, and with the advantages of flexibility and versatility.

A site suitable for electricity generation must meet a number of exacting requirements - and this is true for small stations as well as large stations. Large amounts of cooling water must be available, so stations must either be sited on the coast or major estuaries, or be provided with cooling towers and also be on large rivers for make-up water supplies.

The site must be capable of taking very large loading. Provision must be made for fuel delivery, removal of wastes, and for transmission connections. Land availability and road access must be adequate to permit construction including the transport of large loads.

Fortunately, the CEGB's 4003275 kV interconnected transmission system (the grid) has been developed over many years as a highly integrated and efficient instrument for the bulk transmission of electricity. Within wide limits, it allows stations located at various points in the country to be operated in economic merit order to meet electricity demand anywhere in the country. In doing so, it also allows the requirement to carry margins of spare generating capacity to be kept as low as possible.

And, likewise, the grid gives wide flexibility in choosing new generating sites: generally speaking, if a new site is suitable for a generating station it will be possible to exploit it via a transmission connection into the supergrid (or, for a small station perhaps, into a lower voltage connection).

But, good though it is, the grid cannot function without adequate generation support in each main region. Without that, the grid would be at risk of catastrophic collapse, which can arise from the phenomena known as cascadetripping and voltage collapse. At present, that requirement for generation support to the grid gives rise to an urgent need for new generation in the south of England.

It is neither desirable or practicable to rely wholly on one type of fuel for electricity generation. The arguments on the importance of diversity of fuel type for security of supply are set out below. And, more simply, some sites may be suitable for one fuel and some suitable for another.

So the CEGB is not in the position of being able to build generating stations selected having regard purely to amenity aspects: the basic aim is an economic and secure supply and the practicable limitations must be observed. Rather, the CEGB aims to ensure that each station is designed and operated to an acceptable environmental and safety standard having regard to the particular characteristics of the fuel being used.

It is convenient to have two particular aspects in mind when looking at the characteristics of different types of stations, namely volume, and undesirability of waste products. Different fuels or energy sources give rise to these two characteristics in different proportions.

At one end of the scale come the renewable energy sources - hydro, solar, wind, tides etc. They have a very low density of energy. Hence they entail a very large area of energy capture (with consequential environmental impact) for a significant electricity output, and utilise large amounts of steel and concrete. Volume is large; there are no significant waste products.

At the intermediate level comes generation from fossil fuels. The energy density in a fossil fuel boiler is much higher than for renewable sources; but the volume of fuel required is still large. A 2000 MW coal station can burn over 5 million tonnes of coal per annum. Moreover, there are now substantial waste products: coal ash, dust and other emissions. In addition, new coal fired generating plant will now all be fitted with flue gas desulphurisation plant (FGD), and that entails outputs of gypsum or other sulphur products. While some of this output can be used commercially, the more new coal stations that are fitted with FGD, the more of the output from this process is waste that must be disposed of.

Finally comes nuclear energy, with the highest concentration of all energy in the reactor. Material volumes are small, but it is essential to keep radioactive emissions to very low levels, and reactor contents and spent fuel must be securely contained against the possibility of leakage.

In a sense the problem of undesirability of waste products is more amenable to treatment than the problem of volume. If high volumes are needed, then there is nothing to be done about that. But steps can be taken to ensure that undesirable waste products are contained, or otherwise safely dispersed or disposed of.

In the UK, the greatest attention is given to ensuring the safe design and operation of nuclear stations and the associated fuel cycle processes. The safety aim can be stated simply: if it can happen, it must not matter; if it matters, it must not happen.

SMALL UNITS VERSUS LARGE UNITS

One particular aspect of choosing new generating plant bears particular mention here, namely whether to prefer generating technologies utilising small or large units. The CEGB is often accused of preferring large stations to the exclusion of anything else.

In fact we have no prior preference: it is simply a matter of which of the options available at a given time can best meet the objectives of security and economy. As there is a place for different types of generation, so there is a place for both large units(suitable for base load operation) and small units (which may work at base load but are more likely to work flexibly at part load). But the evidence from the electricity utilities in all the developed industrial countries is that the majority of electricity generation is from large units.

Small units tend to start with a competitive disadvantage. First, the benefits of saving from scale are real; small coal fired units are simply more expensive per kW than large ones. They consume more capital and more land per kW than large units. And although small units can nowadays be built to good thermal efficiencies, there will be some thermal efficiency disadvantage, especially at small unit sizes. That means using more coal, and producing more fly ash and more waste from desulphurisation.

Secondly, the CEGB is already well stocked with small units to take up the part load and peaking duty, as the following table of CEGB fossil fired units shows:-

Thus, since the gas turbine units are certainly small units, the total number of large and medium conventional units is 87, and the total number of small units is 173 (i.e. twice as many). The latter are particularly suited to middle and low load factor duty (though some large oil units also run at low load factors). We have in addition the ten pumped storage units at Dinorwig (6 x 290 MW) and Ffestiniog (4 x 90 MW).

So new small units installed in the UK (whether on the CEGB system or elsewhere) have to show themselves economic against this background of existing plant which also includes a large number of small units.

So if small units are to compete, they must find an edge on the competition. For coal fired units, this could in principle come from finding a site which has particular value for local reinforcement, or from re-use of an existing site with cost saving, or from conversion to co-generation. In practice we have not found it easy to identify prospects under these headings which are economically attractive.

There are also prospects arising from the use of different fuels, in particular gas, eg in combined cycle gas turbine plant. That will depend critically on the price of gas that can be obtained.

In summary, the Board remains willing to consider all such options, but it is for small generation prospects, whether promoted by the CEGB or in the private sector, to show that they can compete.

PLANNING NEW GENERATION

Turning now to the planning of new generation, there are two main questions to be answered:

(i) How big is the electricity demand to be met?

(ii) How should we meet it?

ELECTRICITY DEMAND GROWTH

The demand for electricity is continuing to rise. Over the past four years CEGB unit requirements have grown on average by just under 3% p.a., while peak demand has increased by almost 2% p.a. Moreover, in the first six months of the current financial year, sales are nearly 3.5% higher than in the same period in 1986/87.

The growth of electricity demand since 1982/83 has been better than that expected at the time of the Sizewell Inquiry. Consequently our own forecasts have had to be revised upwards over time. We are now predicting an average growth in both electricity sales and peak demand of over 1.5% p.a. during the next ten years. Figure 1 reveal the extent to which actual demand has oputstripped earlier expectations. In comparison with the Sizewell middle case, demand is now forecast to be of the order of 6GW higher by the mid-1990s. The implication of this is that, even after allowing for the recent reduction in the planning margin to 24%, there will be a requirement for an additional 5GW or so of new capacity; that is the equivalent of more than four stations the size of Sizewell B.

The Industry has raised its forecasts for the medium term for two reasons. First, because of the unexpectedly strong sales growth which has recently been experienced. This has been the result of both the sustained recovery in the UK economy since the recesssion and the strong performance of electricity in the UK energy market, particularly in the commercial sector (where sales have grown by over 6% p.a. since 1982/83). Secondly, the improved performance of the UK economy is forecast to continue into the 1990s albeit at a considerably slower rate (2% p.a.) than experienced since 1982/83.

Following the rapid rise in real fuel prices in the 1970s there has been considerable discussion about the role of energy conservation, its relative merits and its relationship to energy and electricity supply. Broadly speaking 'conservation' measures are defined as all those schemes designed to improve the efficiency of energy use. Recent

experience has shown a significant improvement in energy efficiency, largely brought about as consumers have responded to higher real energy prices. Undoubtedly there is still scope for cost-effective conservation measures to be undertaken in all sectors of the economy. Consequently we build a substantial allowance for efficiency improvements into our demand forecasts.

Overall, our current central view is that the amount of energy required to produce a # of GDP will fall by about 20% over the period from 1985 to 2000. Within this overall projection, we also assume considerable improvements in the efficiency of electricity use. For example our latest estimates to the year 2000 assume large reductions in the average energy consumption of many domestic electrical appliances eg. 22% for televisions, 23% for fridge-freezers and 25% for dishwashers.

It is often suggested that our forecasts should make even greater allowance for conservation. Obviously this would have the effect of moving back the time when we would need to have new power stations on stream in order to meet expected demand. However, in our view the most important mechanism underlying the promotion and take-up of conservation measures is the performance of the economy as a whole. A more buoyant economy fosters the rate of replacement of plant, equipment and building stock used in industry and elsewhere.

There are at present many identifiable opportunities for electricity to make cost-effective substitution for other fuels. Moreover in a faster growing economy, particularly where the bias is towards lighter, higher value-added industry and services, the virtues of electricity, namely versatility, flexibility, cleanliness and high efficiency at point of use, will tend to create further sales opportunities.

THE REQUIREMENT FOR NEW CAPACITY

Given the estimates of future demand, it is a fairly straight forward matter to work out our need for new capacity. By 2000, on latest demand estimates, we need about 13000 MW of new capacity (see Figure 2).

Not all of that requirement need necessarily come from new construction. We continue to examine the possibility of infeeds from Scotland during the fairly limited number of years when the CEGB plant surplus will have disappeared, but when Scotland may still have a surplus. The cross border interconnection capability is limited, and our northern transmission system would need reinforcement: Scotland is not really in the ideal place for a generation infeed. So it needs further study.

Then we may be able to keep some of our existing fossil plant on the system for longer than the 40 years that we allow for in planning. However, that is not just a matter of cost; we would need to be sure that we would retain security of supply if we have to rely on a large tranche of very old plant.

In the main, therefore, we expect to have to meet the requirement by building new capacity. That would not exclude acquiring capacity infeeds from the private sector provided that they were cost effective and did not prejudice security of supply.

DIVERSIFICATION INTO NUCLEAR ENERGY

A new large power station conceived today may take 10 years to take through the planning and construction process, and may then operate for 40 years. So it may still be operating in the year 2037. Consequently the mix of generating plant that we have can change and develop only relatively slowly over time.

But at the same time we must be able to cope with fluctuations in fuel supply - both as regards price and continuity of supply - that, as we know to our cost, can happen to a far shorter timescale. It is evident, just from that alone, that it is sensible to have a plant mix that is capable of burning different fuels, so that we are not over dependent on one fuel as at present, where some 80% of our electricity output is generated from coal and only 16% from nuclear.

Our fossil fuel plant gives us a degree of diversity in respect of burning indigenous coal, imported coal, oil and (with some modifications and subject to Government agreement) gas. However, oil does not look likely ever to be economic for bulk generation of electricity and gas has yet to find a niche in the UK (though the conditions in America currently make gas cheaply available and therefore an attractive fuel for generation).

The one fuel that gives us radical diversity, and also the potential of a very large supply of energy indeed on a world wide scale, is uranium. Hence the importance of continuing to develop our nuclear capability. Indeed, if we do not do so, our nuclear capability will in due course decline and disappear - see Figure 3.

I mentioned our 50 year forward planning horizon. It is always tempting to think that, this time round, forecasting is easy and we shall get our forecasts right. And it is tempting to think that today's conditions of world coal in surplus supply at knock down prices (a situation that only developed some 18 months ago) will go on for ever.

We can dispel that illusion if we go back 50 years, to 1937, and see what forecasts might have been made then.

Still to come at that time was world war two, the 25 year post war recovery period which spread affluence to the masses in a way never experienced before, the development (for the first time outside the USA) of large supplies of cheap oil, the invention of applied military and civil nuclear energy, third world emancipation, the full move to electricity based economies, the oil crisis and the ecological movement.

So what surprises does the next 50 years hold? I do not know, but surprises there will be. So let us be prepared. We cannot adapt our generating plant mix overnight when the time comes; the time to start is now.

CEGB NUCLEAR DEVELOPMENTS

The Sizewell Public Inquiry, including its preliminary and report writing stages, was possibly the longest planning

inquiry on record. From the CEGB's original consent application in January 1981 to consent in March 1987, the total span was six and a quarter years.

At the end of the Inquiry process, the Report by the Inspector, Sir Frank Layfield, found that there was a national interest in building a PWR station at Sizewell, in terms of achieving cost-saving generation of electricity, in contributing to meeting generation capacity in the mid 1990s, and in helping to reduce the CEGB's reliance on one principal fuel (the so-called diversity argument).

The Secretary of State endorsed the economic and strategic case for Sizewell B and gave his consent for its construction on 12 March 1987. In doing so he took account of the Chernobyl accident, and also of the exceptionally low world coal prices prevailing at present - far and away the lowest in real terms for the past fifteen years.

Naturally, the CEGB is pleased at this firm confirmation of its overall case, and there is no need to go over this ground again here. The CEGB expects future PWRS to be economic, the more so as they will avoid the substantial introductory costs associated with the first UK PWR at Sizewell - and also, we expect, the exceptional delay costs associated with the Sizewell Inquiry process.

It is not possible, for practical and logistical considerations, for the CEGB to meet all of the 13 GW requirement with new nuclear plant. The CEGB is therefore looking to a mixed programme of new nuclear and coal fired stations (but not excluding other options). The latter will be based on a new reference design for 900 MW sub critical boilers.

Nonetheless, the CEGB wishes to go ahead as soon as possible with a small family of PWRs which will be near-replicas of the Sizewell design. In August of this year the CEGB applied for consent to build a further PWR station at Hinckley Point in Somerset. Figure 4 shows the sites for nuclear stations currently under consideration by the CEGB.

In closing, it is worth nothing that the Government, which has declared its intention to privatise the electricity supply

industry, has also a manifesto commitment to civil nuclear energy. The Secretary of State for Energy recently endorsed that commitment in his speech to the International Atomic Energy Agency in Vienna, when he stated that nuclear energy would still be required within a privatised electricity industry.

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24 – 27 OCTOBER 1988
LLANDUDNO

55th CONFERENCE PROCEEDINGS

NATIONAL SOCIETY FOR CLEAN AIR
136 NORTH STREET
BRIGHTON BN1 1RG
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55th ANNUAL CONFERENCE
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KEYNOTE ADDRESS
By
The Rt Hon Lord Ezra, Kt MBE

NATIONAL SOCIETY FOR CLEAN AIR
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Mr. Chairman, Lord President, Ladies and Gentlemen: this is a nostalgic occasion for my wife and myself in two ways; first because I am glad to say it is not our first visit to Llandudno. We came here on two or three occasions during my period in the coal industry and were always extremely well received as we have been on this occasion. Secondly, as your Chairman in his very kind remarks mentioned I was of course President of this Society during the period from 1979 to 1981. So, I am delighted to have been invited to this, your 55th conference.

What I would like to do this evening is to take a broad view of the environmental scene in Britain today with special reference of course to clean air - I think we have come to an historic moment in the protection of the environment which it would do us well to ponder over and then to consider what the Society could do to advance the cause which is supported now by more and more people.

The coal industry and clean air

However, before I do that I would like to refer to my old industry - the coal industry - which is frequently associated with atmospheric pollution. I joined the industry in 1947 and it was in fact among the first to welcome the concept of clean air; I remember the awful smog of 1952 and when the legislation which Sir Gerald Nabarro presented to Parliament in 1955-6 was proposed we fully supported it; the coal industry totally supported the concept of the clean air zones and the smokeless areas which were subsequently brought about.

In fact the Clean Air Act probably had a more drastic affect on the nature and appearance of this country than any other legislation in living memory because it cleaned up the cities, and it removed the smog. The coal industry fully supported the legislation even though it meant that people in those areas designated as smokeless could no longer use traditional coal. However, we immediately went into production of fuels which were smokeless and I am sure you all remember the name of Dr. Bronowski who was employed

by us to develop a smokeless solid fuel which would give the appearance in the hearth of a nice flaming product with low ash and emit no soot into the atmosphere; and so that 1956 legislation was a historic landmark in our march towards clean air. It cleaned visible pollutants out of the atmosphere. Since then time has marched on and there has been a battle against the invisible pollutants. And here again I must say that the coal industry, both in my time and I am sure since I left, has tried to battle against that too: the fluidised bed combustion system was devised specifically to retain the sulphurous element in solid fuel in the ash so that it didn't get into the atmosphere. So nobody can say that the coal industry was in any way backward in trying to make sure that its product created the minimum environmental pollution. That's what I would say by way of preface.

Global issues

Since then of course things have marched on and the public both here and abroad have become more and more conscious of the environment and rightly so; the fact is that whereas in the 1950s environmental problems were regarded as a purely localised problem, a national problem; now of course environmental issues have become globalised. This first became apparent with what is now known as "acid rain" - in other words the export of pollution. We had always assumed that with the high stacks of power stations that such sulphur emissions as occurred would not in any way pollute this country, which was true. However, what they unfortunately did was pollute other countries and part of the pollution emitted from our high stacks made landfall in Scandinavia and in other parts of Europe.

Now this was a highly debatable issue as you know, and for quite a long time the government and the CEGB denied that there was any real problem from acid rain. I personally felt that was not a sensible attitude to take - I think if we had from an early stage in this country accepted there was a problem (and there was a good deal of evidence about it) then we could have led the way in the desulphurisation equipment to handle it. As it was when eventually we accepted there was a problem, a large part of the equipment

which now has to be used is of course manufactured elsewhere.

So this was the first evidence of the globalisation of the problem of atmospheric pollution, but globalised in a European sense because there is a limit to which acid rain can be dealt with. Now there is globalisation in a world sense with the problem of the ozone layer and the problem of the greenhouse effect - the greenhouse gases. Both these are subject to a good deal of scientific enquiry but I think it is a considerable testimony to the age in which we live that there is already a widespread recognition that this is potentially a very serious danger, not so much for ourselves in the age in which we live but for future generations. There is talk of both these factors and particularly the greenhouse effect, having some consequence for the world in the early part of the next century: and so we have to consider a new dimension of the environment, the global dimension. It has ceased to be purely a national problem it has become a global problem: that's the first point I want to make.

Britain's role

Now the next thing that I want to say is that if that is so we have got to consider what role Britain is going to play; hitherto I am sorry to say that I have thought that this country in recent years was dragging its feet on environmental matters. We were continually hearing in the House of Lords debates on the subject that, well there may or may not be a problem, that we need more scientific evidence; well you can go on until the cows come home asking for scientific evidence; if you want 100% evidence you probably would never get it and that seemed to many of us to be an excuse for inaction.

However, the Prime Minister made a speech to the Royal Society on 27 September which when added to remarks in her speech to the Conservative Party on 14 October suggested that she is now convinced that environmental issues are of importance. I asked a question in the House of Lords as to whether this meant that the government now in fact attached more importance to this than previously; this was rigorously denied. We have always attached importance

to the environmental issue, I was told and the Prime Minister has simply underlined what we have always done. So it seems that Britain is now going to start leading where it has appeared in certain respects to lag. Leading not only in the acid rain problem, but also the ozone problem and the greenhouse problem.

As far as the acid rain problem is concerned my feeling is that the solutions to it are very clear: we have got to put desulphurisation equipment into existing power stations; this has started to happen but on nothing like the scale in, for example, Germany which is the most comparable country to ourselves and where they have a large number of power stations using fossil fuels: they are spending three or four times the amount we are on desulphurisation equipment. But at least we have made a start and what has been determined is that any new power stations will have this equipment built in.

Fuel efficiency

On the greenhouse problem, the real issue to my mind is not that we can give up using fossil fuels - that's impossible for a long time ahead; the real issue is to use all forms of energy more efficiently. What worries me is that not enough is being done to encourage fuel efficiency. The trouble about fuel efficiency is that people think about it more in times of crisis - when there was the oil crisis of 1974 and another in 1975 everyone talked about fuel efficiency, but now that the price of oil has collapsed the interest in fuel efficiency has diminished; This is short-sighted because sooner or later the price of oil will increase again and in any event from the point of view of the greenhouse effect, energy efficiency is of great importance.

So fuel efficiency is a key area in energy policy in my opinion, and in environmental problems. And then we move on to the other aspects of the problem. There are forms of energy of course which are relatively benign. I believe that fossil fuels will continue to contribute in large measure to the energy requirements of this country and we need to use them more efficiently than before. But there are forms of energy which do not create the same kind of pollution

problem - for instance nuclear power. The trouble with nuclear power, however, is that it has its own environmental problems - it may not contribute to the greenhouse effect but there is the massive problem of radiation to which we need to address ourselves - both the risk of radiation emissions from the nuclear process itself and of course the problems of disposing of nuclear waste. And then there are other forms of energy; for example, in the House of Lords recently we completed a report of these so called "benign" forms of energy and we decided that one of the biggest prospects lay in windpower. This is now being looked at seriously by the CEGB and indeed a paper on windpower energy is being presented at this conference. I think that we should be devoting more resources to those forms of energy which do not add to the greenhouse effect and which could increase our diversification.

Ozone layer

When we come to the ozone layer I am glad to say that this country is now beginning to take a lead and that we have agreed that we have to move a good deal faster than was suggested in the Montreal Protocol - in fact that we will have to work towards the elimination of emissions into the atmosphere of CFCs in order to diminish the impact on the ozone layer.

Coordinated approach

What I believe has to be done now is to look at the whole of this environmental problem, particularly in so far as it affects the atmosphere; this must be done on a concerted basis and not just as individual problems arise. The acid rain problem has arisen; we have argued about it, finally are convinced and now we have done something about it. The greenhouse effect has arisen, we have looked at it and we have decided that we might do something about it and so on. I think we have got to start looking at these things as a whole; we can't just go on being ad hoc about this situation, and so this is my main proposal this evening. There is ground now for a coordinated approach to the atmospheric environment and that this is now urgently required.

However, once you say that then you raise the whole question of an energy policy because you can hardly have a coordinated approach to atmospheric pollution unless you link it to a coordinated energy policy - also the subject of a presentation at this Conference. This is a very important issue because the present government's policy of course is, in matters of energy as in other matters of economic activity, that the whole operation should be market related. I don't object to market relations - I'm all in favour of competition and free trade and the consumer benefitting and the producer benefitting and getting more efficient. But there are certain areas which require a different treatment, and when we come into this very serious area of the environment, and of the atmospheric environment in particular then I believe that we have got to say that market forces are not the solution. Because market forces might bring us to a solution today, which would be very harmful indeed for future generations. So if it is agreed that these are issues which go beyond the straightforward operation of the marketplace, then you are led on to consider whether there shouldn't be a coordinated policy in regard to energy, which after all is the main factor affecting the atmosphere. I think therefore we need to rethink these matters.

NSCA role

I would like to suggest that your Society has now got the opportunity of having a good look at this new historic phase in atmospheric pollution. This phase is that we are moving from the national to the global and that in taking up a global position on the problems of atmospheric pollution, inevitably we have got to start looking at some coordinated energy policy which will link in with, on the one hand the minimisation of atmospheric pollution and, on the other hand, providing people with the energy resources which they need. So I would like to suggest that this might be an appropriate subject for studying - among all the other things that you are looking at - this new historic phase in the whole approach to the environment.

I would like to thank you for inviting me to come along and giving me the opportunity for making these few remarks.

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55th ANNUAL CONFERENCE
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SESSION 2

ENERGY AND THE FUTURE ENVIRONMENT

Chairman
The Rt Hon Lord Nathan

NATIONAL SOCIETY FOR CLEAN AIR
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55th ANNUAL CONFERENCE
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THE POTENTIAL FOR ELECTRICITY FROM RENEWABLE ENERGY SOURCES

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1. INTRODUCTION

The concept that the so called renewable energy sources can make a significant contribution to electricity supply usually evokes mixed reactions. By some they are seen as a cheap, non-polluting benign alternative, by others as hopelessly impractical and uneconomic. In this paper I intend to show that the reality lies somewhere between these two extremes and that by the middle of next century we could have as much as 18% of our electricity supply generated from the "renewables". By this I mean wind, wave, tidal, geothermal, solar and biofuel. With the exception of geothermal and tidal all these sources rely on solar radiation.

I shall concentrate in this paper on wind power which is probably the most promising renewable energy source for the UK but I shall first briefly review the other renewable sources.

2. SOLAR POWER

We should note that the energy captured by the earth from the sun in a couple of months is greater than the world's total coal and oil reserves (1,2). Thus we have plenty of potential to meet our requirements but this potential is thinly spread over the surface area of the globe. Direct conversion of sunlight into electricity using photovoltaic cells is an order of magnitude too expensive to be used for power generation in the UK (3). Indeed the civil costs of separately mounting large solar arrays in the UK itself exceed the present-day-worth of the electricity which could be generated even if the solar cells themselves were provided free of charge. Remote installations and non-grid connected stand-alone units are being exploited however, for example, channel buoys, watches, calculators, toys and garden lighting.

3. TIDAL POWER

This technology was established 20 years ago in France by the construction of the 250MW tidal barrage at La Rance. The best sites in the world for tidal power are the Bay of Fundy in Canada and the Severn Estuary in England and Wales. A barrage on the Severn Estuary would use 192 turbines and yield a peak capacity of over 7000MW (5). Because of the variation in the head available due to the tidal rise and fall, the mean energy production from such a barrage would correspond to that from a nuclear or coal-fired plant with a capacity of just 1600MW. Since the lunar cycle does not correspond to the solar cycle and high tides are not always available when the demand for electricity is at a peak we find that the "firm" capacity would be only about 1100MW. Generation costs from the Severn would be nearly 4p/kWh which is almost double the generation costs from the proposed nuclear power station at Hinkley Point at 2.2p/kWh (6). With an initial cost of over £5000 million the scheme is therefore unlikely to proceed without substantial Government subsidy. Other estuaries such as the Mersey have similar economics, but have significantly smaller potential.

4. WAVE POWER

Wave energy varies between a few kilowatts per metre of wave front to megawatts per metre in stormy conditions. Wave energy collectors have to be sensitive enough to move in resonance with normal sea conditions and yet robust enough to withstand North Sea storms. Despite the large resource potential of some 45TWhpa, i.e. about 20% of CEGB output, no large scale wave energy device has been studied in detail which could yield electricity at less than about 8p/kWh (7).

Small scale devices mounted at the bottom of cliffs in deep water with a small tidal range are significantly cheaper but the resource potential is much less.

5. GEOTHERMAL

There are over 5000MW of geothermal electrical generating plant worldwide (8) and in volcanic regions this is usually a very economic source of electricity. Countries such as New Zealand, Italy, California have all established geothermal industries.

In the UK, geothermal aquifers are relatively cool - only about 70 to 80 C - so the alternative "hot dry rock" process is the only feasible source of geothermal generation. In certain areas, such as Cornwall, there is a higher than average temperature gradient, with temperatures of 180 C - 200 C at 6km depth. The heat can in principle be harvested by drilling a borehole, cracking the rock, intersecting the crack matrix with a second borehole and circulating water. The overall efficiency of electricity generation would be only about 5% and so large quantities of heat would have to be rejected. In addition there are potential environmental issues with radon emission. This technology is at the embryonic stage (only a 2km deep reservoir has so far been explored) but a resource potential of 10TWhpa could be exploited next century if the technology can be developed (9). The Government has just announced a further £8M grant for the work at Rosemanowes Quarry in Cornwall. The technology may be extended to rocks other than granite, if the programme is successful and drilling technology makes deeper boreholes economically possible.

6. BIOFUELS AND WASTE

Biofuels are those which are directly derived from biological sources, often termed "biomass". There are two potential sources: organic wastes including refuse, industrial wastes, forestry residues, straw and animal manures and energy crops grown specifically for energy production. Wastes also contain combustible material such as plastics which contribute to noxious emissions. The Department of Energy estimates that between 4 and 15 Mt coal equivalent per year of biofuels could be economically exploited in the UK. Some of this would be used for heat production, some for electricity production and some for combined heat and power systems.

Biofuels are little exploited in the UK at present and most refuse is disposed of in landfill sites. Such sites produce methane which can be hazardous. Thus in extracting methane for safety reasons, the opportunity arises to burn it and utilise its energy. Currently 19 landfill sites in the UK extract methane commercially, about a third of these generate electricity the others use the gas for heating.

In the future refuse combustion for electricity generation may be more exploited as landfill sites near to metropolitan centres become exhausted. Combustion temperatures tend to be lower and hence particular attention will have to be paid to limiting noxious, gaseous emissions from such sites. Currently there are four refuse incineration plants with energy recovery in this country.

7. WIND POWER

7.1 Experience Worldwide

Rapid progress has been made in the deployment of wind turbines in the USA during the last decade (cf Figure 1). Currently 15000 machines are installed there. Some of these machines were "cowboy" installations and have not been successful. However, later designs have worked well and we are now receiving encouraging reports from the utilities and the Electric Power Research Institute which show availabilities exceeding 95% (10). The Wind Energy Group of the UK, has reported particularly encouraging results from the first year's operation of its Californian wind farm in the Altamont Pass.

About 1400MW wind turbine capacity is now installed in California, mainly in the Altamont Pass. This means that about 1% of Californian energy demands are now met from the wind. It should be noted that the wind blows most strongly in the Altamont in the afternoon in the summer which corresponds to the peak demand on the system from the air conditioning load in the cities.

7.2 Cost Experience

In parallel with the rapid expansion of wind farms, costs have fallen significantly - by a factor of about two during this decade (11) (cf Figure 2). With the terms currently offered by US utilities, entrepreneurs can pay back their investment within 5-10 years. At the price levels now prevailing in the USA (about $1500 per kW, i.e., about £800 per kW installed) wind power could be economic on windy sites in the UK provided that machines continue to have a high availability over their design life of 25 years. The greatest uncertainty is over lifetime maintenance costs, because large wind turbines have not been in operation for more than four or five years anywhere and we do not know whether high maintenance charges, for instance for machine reblading, will materialise in later years.

7.3 Cost Projection

Wind power economics are critically dependent upon mean wind speed. The energy which can be extracted increases as the cube of the wind speed. Thus the commercial viability of wind power depends upon being able to find large numbers of windy sites. These tend to be on windswept hillsides which are often cherished for their scenic beauty.

The wind does not blow all the time even in windy areas. The "load factor" for a wind turbine is the ratio of the actual energy produced to that which would be produced if the generator operated at full output, 24 hours a day, 365 days a year. For a typical wind turbine, the load factor is about 42% at 9m/s windspeed but falls to 20% at a windspeed of 7m/s. So for a 100% reliable machine having a nominal capacity of 1000kW, we will have an equivalent capacity of 420kW at 9m/s but only 200kW, at 7m/s. This highlights the fact that the price we can afford to pay for a machine falls off rapidly at lower windspeeds. We estimate that the load factor for our wind parks will be between 30 and 40%.

In order to assess the economics of wind power we need to estimate how much electricity will be produced from the wind in terms of windspeed and machine availability and then

make an allowance for the operation and maintenance costs of the wind turbines. We must then assess how much fossil fuel will be saved by this wind generation over the next 25 years. If we bring these savings to present day worth at 5% discount rate then Figure 3 shows the capital costs at which wind power would just break-even. For example, for a windspeed of 8m/s, £800/kW installed should just be economic at a 5% TDR. We suspect that our wind parks will cost about £1000/kW installed so we do not expect them to be economic even if they work perfectly. So manufacturers must aim at lower capital costs especially if we are required to achieve higher rates of return on capital investment.

7.4 Land Requirement

The Board has carried out preliminary studies on the distribution of average windspeed over the windiest areas. In general terms one could expect to achieve 4MW of wind power capacity per sq km, about 10MW per sq mile. We estimate there are about 2800 sq miles of land with windspeeds above 8m/s, which would give an installed nameplate capacity of 28GW if every square mile were planted with wind turbines. This would be equivalent to about 13 GW of nuclear plant. For windspeeds between 8m/s and 7.7m/s there are a further 1800 sq miles of land (4500 sq km). Fully planted this could yield a further 18GW of wind power which would be equivalent to about 7GW of nuclear plant.

It is a fact of life that high windspeed tends to go with mountainous areas and scenic beauty. The best resource lies in some of the most beautiful countryside, national parks, etc. Clearly nothing like all of this land could be dedicated to wind power. How much land could actually be made available depends largely on public opinion. One of the main reasons for our present programme is to establish just this. If only 10% of these windy areas were made available, then 2000MW equivalent plant capacity could be supported. Most of this could compete economically with coal-fired power stations but perhaps only 300MW - 400MW would be cheaper than Hinkley Point C nuclear power station.

7.5 CEGB/D.En Programme

The programme announced by Lord Marshall in March contains the following elements:-

The Board has formally designated the Carmarthen Bay site, Figure 4, as the Board's Wind Energy Demonstration Centre. With the opening of the Visitors Centre there later this year we expect that it will become a focus of much interest for wind power. The site will be used to test candidate machines for the three wind parks.

At the same time the processes will be put in hand for the planning consents and acquisition of the three sites so that we will be in a position to erect machines on the first site in about 1990. The other two sites will be developed in 1991 and 1992 and, if all goes well, commercial extensions of these or other sites could be a reality by 1995.

British manufacturers have produced a number of commercial designs of wind turbines some of which have already been deployed in California. Figure 5 shows the Howden 300kW machine which is situated at our demonstration site at Carmarthen Bay and this is one possible type of machine which will be considered for the demonstration wind parks.

Wind Energy Group (WEG) is developing a 2-bladed 300kW machine which it is proposing as the successor to its 3-bladed 200kW machine which has been successfully deployed in California. We hope that the first of these machines will be installed at Carmarthen Bay later this year so that we can have first hand experience of it before deciding whether to deploy it in one of our demonstration wind parks.

Another option for the wind parks would be the vertical axis wind turbine, a pilot version of which has been installed at Carmarthen Bay since 1986. We are currently discussing with VAWT Limited whether we should host a 500kW version of this machine at Carmarthen Bay.

When searching for commercial wind power sites we need to look to the western extremities of the country and to high ground. Naturally we have to exclude cherished landscapes,

conurbations, communications links, airfields and other protected land. The three shaded areas in Figure 6 seem to be the most promising. In order to establish the viability of wind farming we are therefore planning to build a demonstration wind park in each of these areas:-

Cold Northcott near Launceston in Cornwall
Capel Cynon near Carmarthen in Wales
Langdon Common, south of Durham

The Langdon Common site may be contentious because it involves land recently designated as an Area of Outstanding Natural Beauty and also the fringe of a Site of Special Scientific Interest. However, the potential for wind farming in the Northern Pennines is large and if it could be established that this was an acceptabe way of farming the wind in a rural, depressed area then as much as 1000MW of wind power could be accommodated.

7.5 Visual Impact of Wind Parks

Early developments in the USA were carried out by speculators and frankly many of them looked messy! More recent developments however have been more carefully carried out and the Howden wind farm in California now fits much better into the landscape. Figure 7 shows a more recent development in Holland on a wind power site at Sexbierum. The machines are clean lined, attractive and elegant. The minimal impact of wind farming upon normal agricultural practices should be noted.

In hilly country, wind turbines would not be sited in straight rows, but machine spacing would be varied to suit the topography. Figure 8 shows an artist's impression of what one of the Board's demonstration wind farms would look like. This is the impression of the Langdon Common site; the wind turbines integrate well into the moorland landscape with minimal visual instrusion.

A recent small scale public opinion survey carried out for the Board established some interesting preliminary conclusions about public attitudes to wind power. Most important, only about 12% of people have ever seen a modern wind turbine.

This underlines the need to demonstrate wind power to the public. People seem to like the slim, elegant high technology designs now available. These conclusions will be tested by our programme.

Public opinion surveys will be mounted around the three wind power sites before, during and after construction. Each wind park will contain a Visitor Centre and this will be used both to explain the plans to the public and also as a further method of eliciting their views.

7.6 Offshore Wind Power

The largest potential renewable energy resource in Great Britain is offshore wind power, which could in theory provide over 200TWh of electricity per annun (12). This is comparable to the electricity demand in England and Wales. In practice only 10-20% of this could easily be integrated into the CEGB system because of technical problems associated with the intermittent nature of the wind (13).

To date, thinking has been that offshore wind energy will be too expensive to be a contender. However, a reappraisal by the Board has suggested that medium sized wind turbines erected in shallow water on steel structures may have economic potential. Support has therefore been secured from the European Commission, the Department of Energy, the Eastern Electricity Board and James Howden and Company to build the world's first truly offshore wind turbine. This will be a 750kW production wind turbine standing on a steel tripod some 5km off Wells-Next-the-Sea in North Norfolk (cf Figures 6 and 9). This will help to establish the true operation and maintenance costs of offshore wind turbines and if these can be contained then we may see offshore wind parks becoming a commercial reality towards the end of the 1990's.

7.7 Possible Wind Power Capacity by 2005

If things go well and if economic and social criteria are met then this programme should pave the way for 1000MW of wind power in the UK by the year 2005. This will meet about 1% of the nation's electricity requirements. Although

this does not sound a lot, we must remember that it corresponds to power for half a million people and an alternative to burning nearly one million tonnes of coal each year. That must be good for the environment in the long term.

But achievement of this target depends on the crucial factors mentioned above: reliability, maintenance costs, capital costs - most of all on public acceptability.

8. CONCLUSIONS

Overall, if all the technologies mentioned reach technical maturity and become both economic and socially acceptable then it is possible that up to 18% of electricity might come from the renewables by 2030 (14). This projection is shown in Figure 10.

To return to my opening remarks. Renewables certainly have an important part to play in satisfying the energy needs of this country and are already competitive at the margin. But it would be unrealistic to expect that they could supply the major part of the energy needs of a society such as we all live in. These will still have to be provided by fossil and nuclear energy.

REFERENCES

1. Survey of Energy Resources, 1980. 11th World Energy Conference, Munich, 11-18 September 1980. Part A, p 5.

2. Twidell, A.J; Weir A.D. Renewable Energy Resources. E and F N Spon, London and New York, 1986. p 5.

3. Anon. 1986 Appraisal of UK Energy Research Development and Demonstration. Energy Technology Support Unit, Harwell. ETSU R43. February 1987. P B154.

4. Anon. Prospects for UK Renewable Energy Technologies. Review, the Quarterly Journal of Renewable Energy Technology. Department of Energy. September 1987. pp 4-5.

5. Anon. Tidal Power from the Severn. Severn Tidal Power Group. Volume I, January 1986, p 87.

6. Anon. Hinkley Point C Statement of Case. The Requirement for Hinkley Point C. Part 2. Non-Fossil-Fuelled Generation Options - Renewable Sources - Tidal. Paragraph 2.38, p 19. CEGB, London, 1988.

7. Anon. Wave Energy: The Department of Energy's R&D Programme 1974-1983. Energy Technology Support Unit, Harwell. ETSU R26. March 1985.

8. Taylor, R.H. Alternative Energy Sources for the Centralised Generation of Electricity Adam Hilger Ltd, Bristol, 1983. p 224.

9. Anon. Renewable Energy in the UK: The Way Forward. Energy Paper 55. Department of Energy, London. HMSO, 1988. Figure 2, p 4.

10. Lynette, R. Wind Power Stations: 1985 Performance and Reliability. Final Report June 1986. EPRI AP-4639. Electric Power Research Institute, Palo Alto, California, USA.

11. Lynette, R. Status of the US Wind Power Industry, October 1987, International Conference on Windfarms, Leeuwarden, Netherlands.

12. Milborrow, D.J; Moore, D.J: Richardson, N.B.K; Roberts, S.C. The UK Offshore Wind Power Resource. Proceedings 4th International Symposium on Wind Energy Systems, Stockholm, 1982. BHRA Cranfield.

13. Wright, J.K. CEGB Proof of Evidence to the Sizewell Inquiry. On: Alternative Methods of Electricity Generation, CEGB P3. November 1982. Paragraph 10.

14. CEGB. Prospects for Alternative Energy Sources in Electricity Generation. Contained in Session 1987-88 16th Report with Evidence of the Select Committee on the European Communities, Alternative Energy Sources. June 1988.

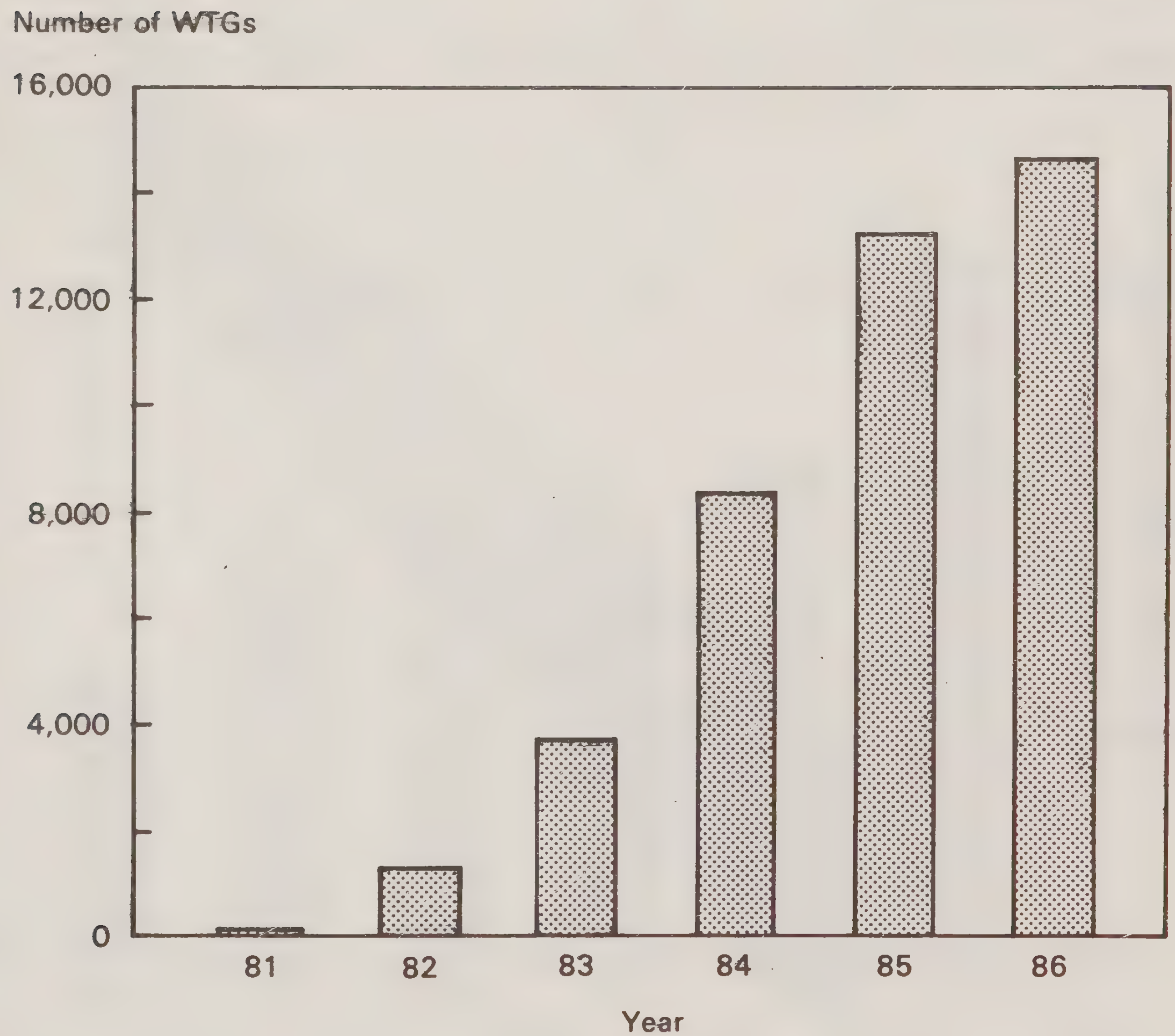

Fig. 1. Cumulative Number of Installed WTGs (California)

(From Status of U.S. Wind Power Industry, October 1987 by Robert Lynette, International Conference on Windfarms, Leeuwarden, Netherlands)

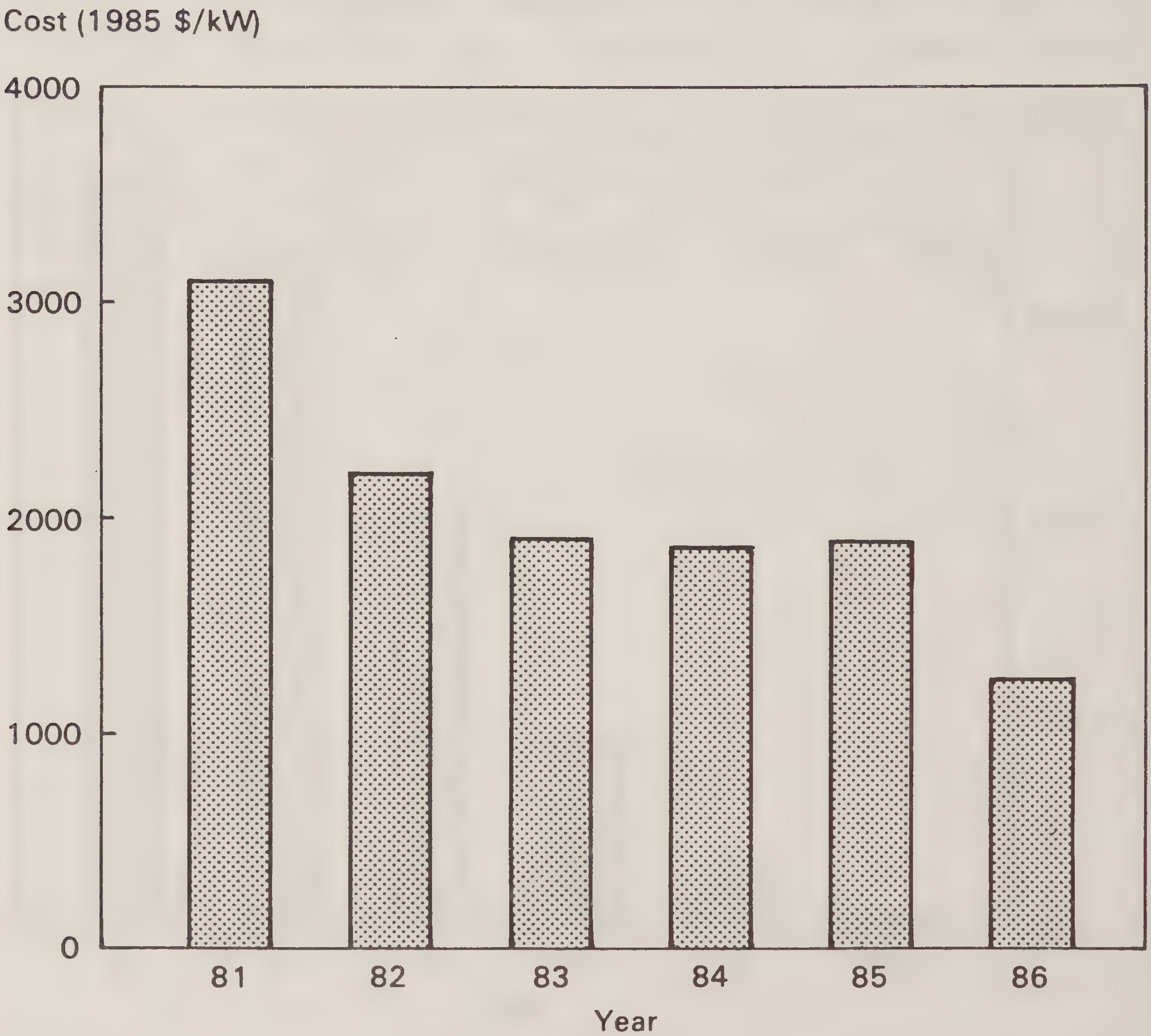

Fig. 2 Average Installed Capacity Cost (California)

(From Status of U.S. Wind Power Industry, October 1987 by Robert Lynette, International Conference on Windfarms, Leeuwarden, Netherlands)

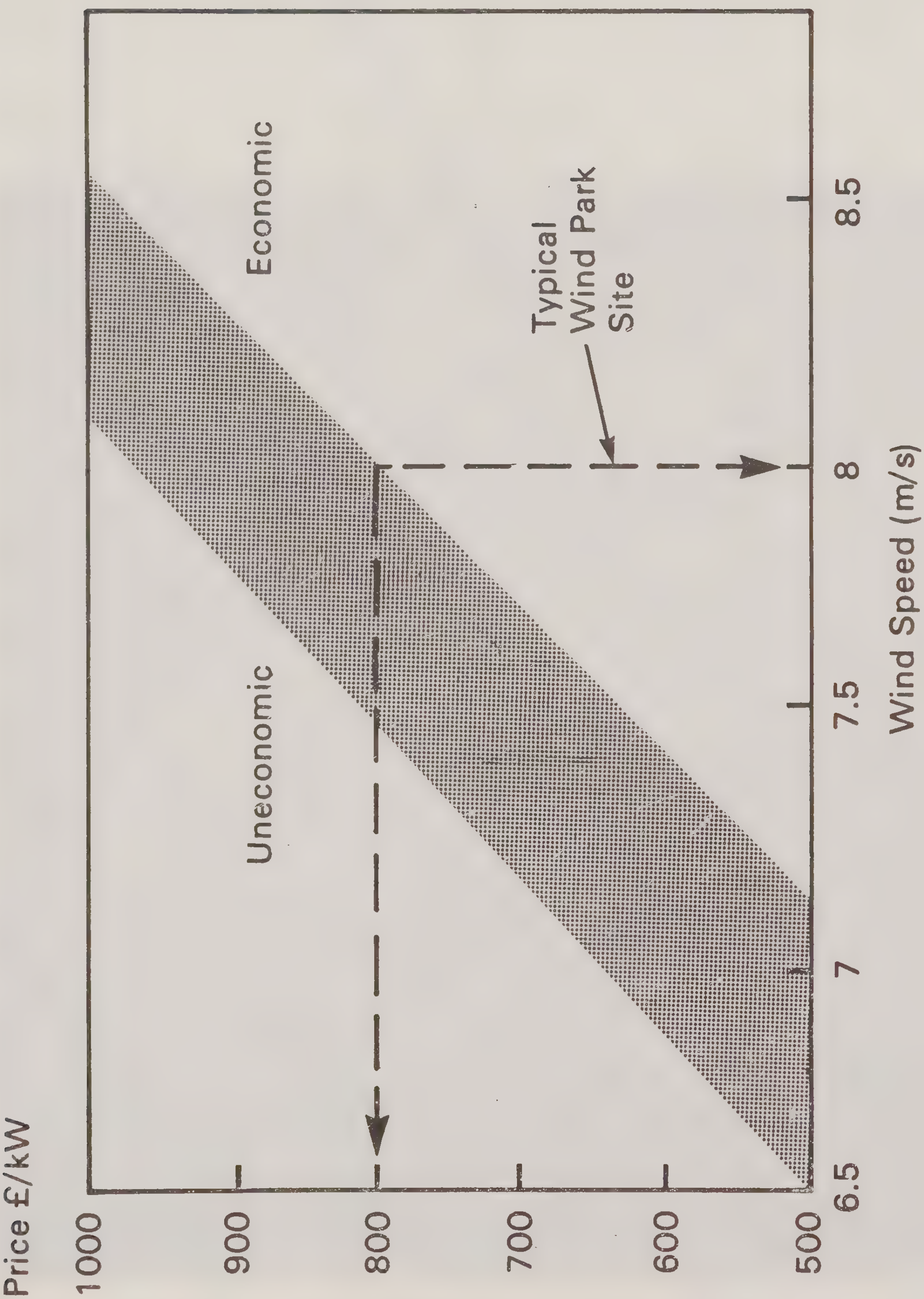

Fig. 3. Wind Power
Break-even Capital Costs

FIG.4 - Aerial photograph of CEGB wind energy demonstration centre at the Carmarthen Bay power station site in Burry Port, South Wales.

FIG.5 – A 28m diameter 3 bladed 300kW 25m hub height machine built by James Howden & Co (foreground) at the CEGB wind energy demonstration centre Burry Port in South Wales.

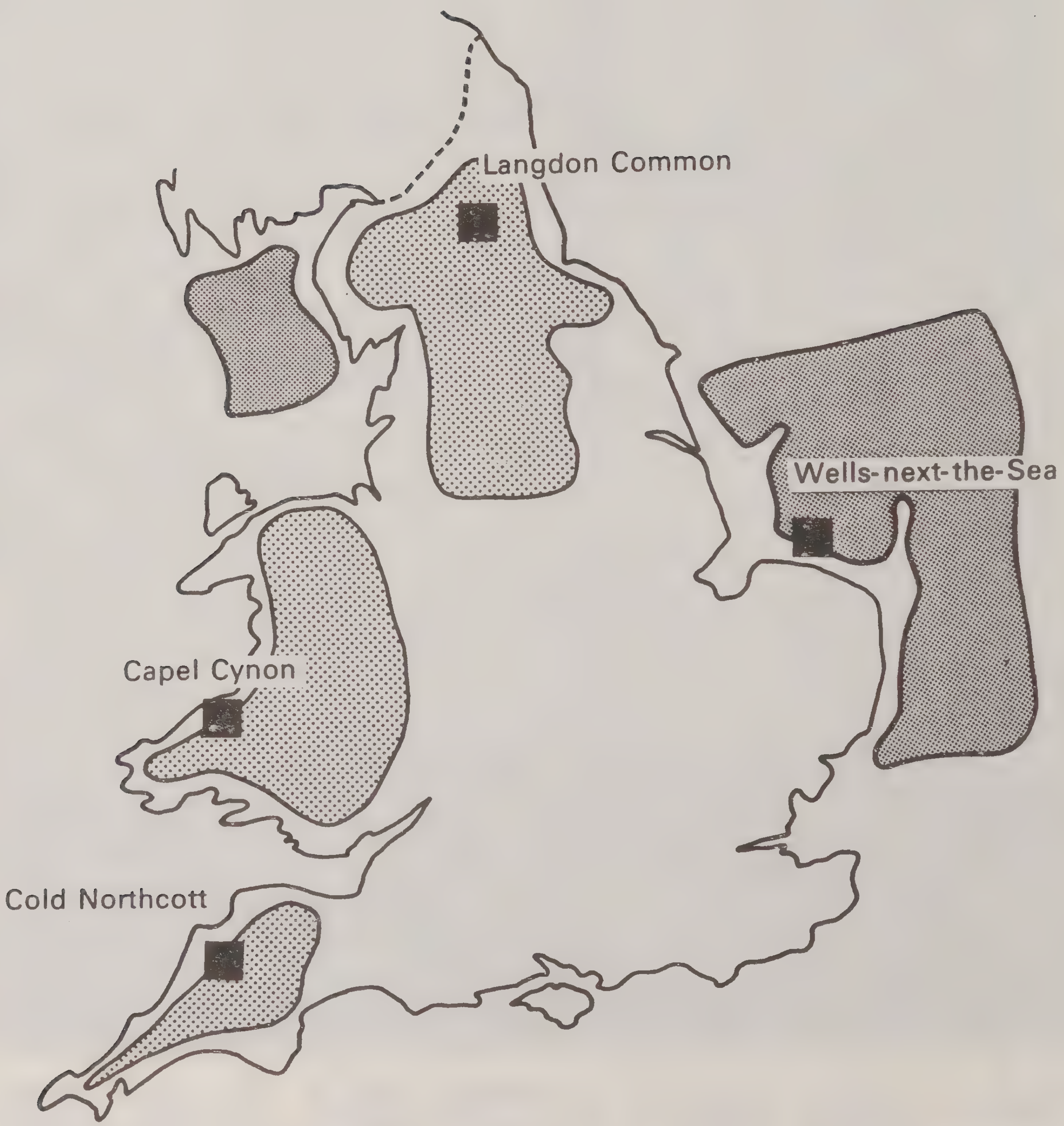

Fig. 6. Location of High Winds

FIG.7 - Sexbierum wind farm in Holland. 18 wind turbines 30m diam. 35m hub height; rated power 300kW each. Made by Dutch firm of HOLEC.

FIG.8 - PROPOSED LANGDON COMMON WIND PARK

An artist's impression of the proposed wind park at Langdon Common, County Durham jointly funded by the CEGB and the Department of Energy. The development of 25 horizontal or vertical axis wind turbines, each of 300-500 kilowatts, would occupy an area of three to four square kilometres. The impression shows horizontal axis machines in a possible layout which would be determined from the site investigations.

FIG.9 - Artist's impression of 750kW offshore wind turbine to be built 5km of Wells-Next-the-Sea in North Norfolk. (Joint project with CEGB DEn CEC EEB and James Howden & Co).

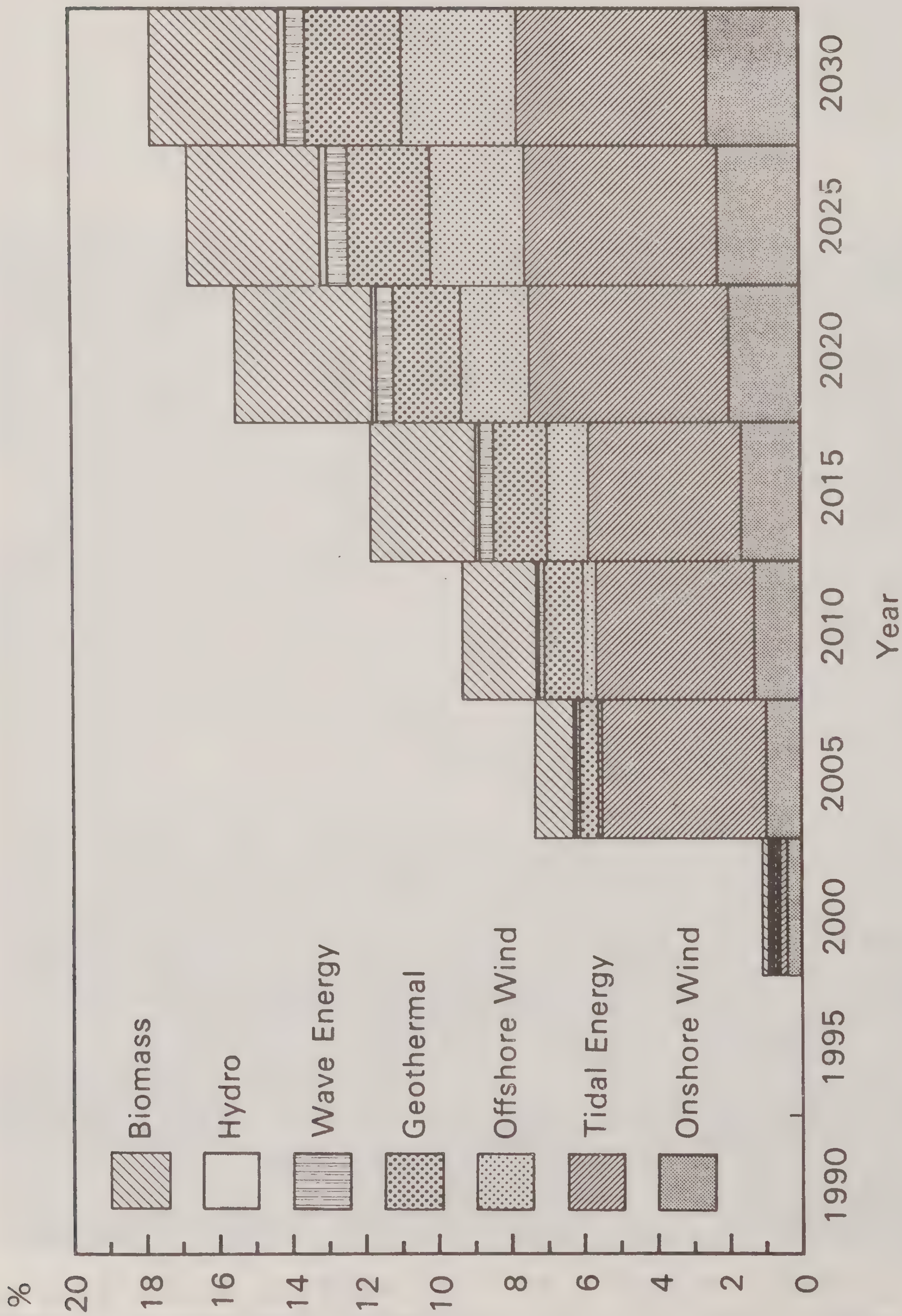

Fig. 10. Upper Limit of Renewable Energy Contributions as % of Likely U.K. Electricity Demand

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CONSERVATION VERSUS GENERATION

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INTRODUCTION

An invitation to talk on the subject of conservation versus generation is perhaps a hint to do something more. The adversarial formulation of the title suggests a quasi-legal process in which evidence will be weighed and a verdict pronounced at the end of the paper. However, I intend to upset precedent by pronouncing my verdict right at the start of the process. And that is that the offending word in the title is 'versus'. The premise underlying this paper is that energy conservation and the construction and operation of various forms of electricity generating capacity are complementary tools in ensuring that the needs and aspirations of consumers are met economically and securely.

However, there are still key questions which need to be addressed. Is there at present a proper balance between the development of the potential for generation and conservation in the British Electricity Supply Industry (ESI)? And, if not, what policies would serve to redress the balance?

These questions cannot be given proper consideration without examining the wider context in which policy is made. Accordingly, before the scope for generation and conservation opportunities are considered, the major issues currently facing the ESI will be discussed.

THE POLICY CONTEXT

Three sets of questions will be addressed. The first, and most important, is electricity privatisation. The second is the need, perceived by the Central Electricity Generating Board (CEGB) and the Government, to install large amounts of new generation capacity by the end of the century. The third is the recent interest shown by the Government in

environmental issues and the possible impacts on energy policy.

Privatisation

Privatisation has been discussed at length elsewhere, and only those features of the Government's proposals (1) which hold implications for the balance between conservation and generation are noted here. These are:

a) the movement of the centre of gravity of the ESI away from the generation function towards distribution;

b) the breaking up of the CEGB into three parts -- TransCo which will own the transmission network, 'Big G' which will own 70% of the generation assets, including all the nuclear stations, and 'Little G' which will own the remaining 30%;

c) the transfer of the obligation to supply electricity from the CEGB to the distribution companies which will be created from the present Area Boards;

d) the institution of formal contracts which will determine the flow of electricity between the generating companies, TransCo and the distribution companies. These will replace the internal 'command and control' arrangements presently practised within the CEGB;

e) the proposed requirement on distribution companies to contract for a minimum proportion of non-fossil fuel capacity which may be set at 20%; and

f) the creation of a regulatory body, OFELEC, which will oversee the setting of electricity prices and the contracts established between the different components of the new industry.

The implications of these features cannot be assessed until the Electricity Bill is published next month. Even then, much may remain unclear until the Licence conditions for

successor companies are set. The important point is, however, that the major changes proposed for the ESI provide a unique opportunity to weld institutions and institutional arrangements which can address questions about the balance of electricity conservation and generation, if that course of action is desired.

The Need for New Plant

Once the CEGB completes the commissioning of nuclear power stations currently under construction, the capacity of power stations in England and Wales, including those placed in reserve, plus firmly contracted external supplies from France and other sources, will be 64,200 MW. (2). This exceeds the maxiumum system demand met in 1987/88, 46,900 MW, (3), by 37%. Even allowing for a margin of 17% to allow for plant breakdowns at time of peak demand and variability in weather conditions, plant availability still exceeds plant need by over 9,000 MW.

In spite of the large present surplus of generating capacity, the CEGB is forecasting a need for around 12,000 MW of new plant by the end of the century. Table 1 shows how this figure is arrived at. The CEGB sees a need to replace up to 9,400 MW of plant which, on the basis of present accounting lives, is due to be retired between now and the end of the century. Peak winter demand is forecast to increase by 7,000 MW, carrying with it an increase of 1,200 MW in the reserve margin. Finally, forecasting uncertainty contributes 3,500 MW to the suggested plant need. The total additional amount of capacity required, 21,100 MW, is offset by the present 9,300 MW surplus from existing and committed plant.

Electricity demand will be discussed in detail later. At this stage it may be noted that: a) many factors other than electricity demand affect the assessment of plant need; and b) almost all of the elements of the capacity need are subject to major uncertainties. For example, 6,000 MW of the projected plant retirements involve fossil fuel stations which could be retained in service for longer than their present nominal operating lives. It is also conceivable that the ESI's planning margin might be re-assessed. Such a step

is hinted at in the CEGB's evidence to the Hinkley Point C Public Inquiry. It is possible that assumptions about the availability of plant at winter peak and the length of the planning horizon could be re-examined.

The Greening of the Government

The Prime Minister's speech to the Royal Society in September was the most dramatic manifestation so far of the recent cultivation of the positive aspects of British environmental policy. The Environment Minister, Lord Caithness, in a message to the Toronto conference on global climate change in June, (4) spelled out a number of poicy themes which would need to be addressed if the climatic effects of energy production and use are to be controlled. These included the pricing of energy at its true cost, the encouragement of cost-effective measures to promote the efficient use of energy, and the promotion of nuclear power and other non-fossil energy sources. These themes were echoed in the Government's July response (5) to the Brundtland Report on 'Our Common Future. (6)

As well as the Department of the Environment suggesting energy policy themes, there is also the novel spectacle of the Department of Energy apparently making environment policy. The non-fossil quota to be imposed on the electricity distribution companies after privatisation is now being cited as a contribution to efforts to reduce acid rain and carbon dioxide emissions.

The extent to which these new elements of Government policy can, or will, be reconciled with the Government's belief in allowing market forces to determine energy supply and demand decisions remains to be seen.

ASSESSING CONSERVATION AND GENERATION

In this section, the relative merits of electricity conservation and generation are assessed. There are four elements to the comparison:

a) the technical potential for the two approaches;

b) the economic evaluation;

c) an assessment of the environmental impacts; and

d) a consideration of the institutional factors which might promote or obstruct an economically balanced development of conservation and generation opportunities.

Technical

There is little need to talk about the technical potential for electricity generation. There are ample capabilities for building power stations in Britain, not only in the CEGB and the Scottish utilities, but also in a number of firms in the engineering sector.

While the exact scale of the technical potential for energy conservation is open to more debate, there is a widespread consensus that it is large, and that across a range of industries and services the capabilities for achieving it are present. One of the principal conclusions from an EEC-funded study of energy use and efficiency in the North West of England was that: 'across the country, energy equivalent to ten Sizewell B power stations is readily available for a fraction of the cost of ... any ... supply side option'. (7)

In terms of electricity in particular, a number of specific examples (8) serve to underline this assertion:

a) standard incandescent lights have remained fundamentally unchanged since the 19th century and produce more heat than light - fluorescent lamps can cut electricity use by up to 75%;

b) the range of efficiencies of the major appliances which account for most of the electricity use in the typical gas-heated home is remarkable. The worst fridges and freezers on the market consume three times as much power as the best, while the range for washing machines, tumble driers and dishwashers is roughly two to one; (9)

c) better design of electric motors could cut power consumption by up to 15%;

d) many homes and buildings using electricity for space heating are still poorly insulated, particularly those owned by local authorities; and

e) better design of new buildings, and the retrofitting of existing commercial and institutional buildings could cut heating and air conditioning needs substantially, particularly where the recent large-scale expansion of the use of computers and office automation equipment has added significantly to incidental heat gains.

Economic

At present, the ESI may justify investment in new power stations on the basis of a 5% real rate of return on capital. Even a higher return of 10%, which is sometimes discussed in the context of privatisation, is low compared with rates which might be demanded in the private sector. The point about the discrepancy between rates of return available on investment in energy supply and energy demand has been made repeatedly by many commentators. However, it is worthwhile reiterating.

The North West Energy Study already mentioned, (10), and others, have shown that the potential for electricity saving measures with paybacks of less than two or three years is large. A two year payback on a measure with a life of five years is equivalent to a rate of return on capital of about 40%, which compares extremely favourably with investment in electricity supply.

To put it another way, the capital cost of installing sufficient electricity generating capacity to meet evey additional kWh of electricity demand is 2 - 25 pence. The capital investment required to reduce demand by the same amount is only around 10-15 pence. This comparison is an extremely conservative one in that it ignores operating, transmission and distribution costs which would tip the

balance further in the direction of conservation as a cost-effective investment.

The imbalance in investment in electricity supply and demand represents a market failure in the allocation of capital resources. Where such failures exist, there is always an opportunity for entrepreneurs to step in and realise some of the potential profits. This has begun to occur to a limited extent through the emergence of Contract Energy Management (CEM) companies which can appraise the scope for energy conserving measures at industrial sites and commercial buildings, finance the implementation of energy saving schemes, and share the cost savings with the consumer.

Environmental

Increasingly, energy policy options are being justified and reinforced by reference to the types of environmental benefits which may flow from them. Energy efficiency and the use of nuclear power have already been mentioned as examples of these.

However. all forms of electricity generation have some kind of environmental impact (11) which can only be summarised in the briefest way:

a) <u>Siting and amenity</u>. The large power stations which the CEGB has preferred require large tracts of land which must be sited in rural areas close to sources of cooling water on the coast, on rivers or lakes. Nuclear stations are generally sited in particularly remote areas for safety reasons. This siting policy has major wildlife and amenity implications.

b) <u>Atmospheric emissions</u>. While the problem of dust emissions from coal-fired power stations is largely solved, emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) are linked to acid rain. Carbon dioxide (CO_2) is one of the gases which is contributing to the global greenhouse effect. Power stations in Britain are among the major contributors to emissions of all these gases. The scope for

controlling these emissions varies greatly. 90% of SO_2 emissions will be removed by flue gas desulphurisation (FGD) at new power stations, while the use of low-NO_x burners will cut NO_x emissions by around 40%. Denitrification plant which could reduce NO_x emissions by up to 80% has been installed in Japan and the FR Germany but is much more expensive. However, there is no feasible technology for reducing CO_2 emissions.

c) Fossil-fuel wastes. For each tonne of coal burned in a power station, about 500 kg of spoils are created and 170 kg of pulverised fuel ash (PFA) produced. The use of FGD will aggravate the problem of solid waste disposal by generating 100 kg of gypsum for every tonne of coal used. About 40% of present PFA production is used as an aggregate, while it should be possible to market gypsum for the production of wallboard. However, more than a few FGD units would quickly saturate the UK markets. The use of advanced coal combustion technologies, particularly fluidised bed combustion, could exacerbate waste disposal problems.

d) Radioactive wastes. The problem of disposing of radioactive wastes from the different parts of the nuclear cycle - operations, fuel processing and decommissioning - presents extremely difficult political problems as evidenced by the abandonment of NIREX's search for disposal sites just before the last General Election. Apart from low-level wastes at Sellafield, other radioactive wastes are currently being stored at the site of origin until political difficulties can be resolved.

Switching from one form of electricity generation to another can serve to reduce some of the environmental impacts listed above, while increasing others. Inevitably, the choice of different forms of electricity supply involves trade-offs, as recognised in the 'best practicable environmental option' approach. However, it is only increased electricity efficiency which promises to reduce all of the environmental impacts mentioned above.

Institutional

The point of balance which is established between efforts to promote electricity conservation and electricity generation depends primarily on the institutional factors which come into play. Table 2 lists those factors which may play a role in promoting or impeding the construction of new generating facilities.

The ethos of the ESI is a crucial factor explaining pressures to build more power stations. The industry's business is to generate and sell electricity, and it is a natural goal to strive to do so more effectively and in greater quantities. In public ownership, the ESI has had access to capital at very low cost. In addition, the capital has also been risk-free, in that the costs of any mistaken investment decisions have been passed on to the electricity consumer, rather than being absorbed by the share-holder, in this case the Government. The costs of the Advanced Gas-Cooled Reactor Programme and the oil-fired stations which were constructed in the late 1970s fall into this category.

While access to low-cost, risk-free capital will soon dry up, some features of the privatisation proposals are likely to reinforce the incentives to build power stations. The Government's general commitment to the promotion of competition in electricity generation falls into this category. Competition cannot exist without competitors. Already a range of proposals have been made for new power stations during the 1990s, including the CEGB's proposals for large stations at Hinkley, Wylfa, Fawley, West Burton and Kingsnorth and three smaller gas-fired stations. Independent generators and Area Boards have also made proposals for smaller coal-fired power stations and gas-fired combined cycle plant.

The proposed non-fossil generation quota may also serve to stimulate the construction of plant for diversity reasons which might not have been built on the grounds of capacity need alone.

Finally, if the 'RPI-x' (x% below inflation) type formula used

to regulate gas and telephone charges is applied in one form or another to the electricity distribution companies after privatisation, this could lead to higher electricity sales. A proportion of the costs of electricity distribution and transmission are fixed and do not increase if sales expand. Thus, the revenue received by a distribution company from each additional unit of electricity sold under an 'RPI-x' regime could well be in excess of the associated costs. Economic incentives to promote the increased use of electricity would therefore be created.

These factors are balanced by the difficulties of obtaining planning permission to develop new sites, as evidenced by the enormous local opposition to the proposed new stations at Hinkley and Fawley. Lengthy public enquiries are likely at both sites and already there are rumours that the Government may put the Fawley project on ice until after privatisation. The high capital requirements of the ESI are also likely to be a disincentive to private sector investors.

On balance, it is likely that privatisation will weaken, but not eradicate pressures to construct new power stations. One consequence of the desire to sell more electricity while, on the other hand, investing as little capital as possible, may be to promote the greater use of off-peak electricity.

Table 3 examines the institutional factors influencing the adoption of electricity efficiency measures. The recognition of business opportunities by CEM companies is a positive factor, as has been the publicity produced by the Energy Efficiency Office (EEO). The recent relaxation of Treasury rules on third party financing of energy conservation in the public sector will also help. The Government's recognition of the environmental benefits of energy conservation may be significant in the future, but the translation of policy interest into specific measures is still awaited.

The obstacles to electricity efficiency are varied. Because of infrequent meter-reading and billing, electricity is, for most consumers, an 'invisible' good. Consumers generally do not know the true costs of running their heating systems and appliances and hence the information required to make market forces operate does not exist. This fact reinforces

the high degree of consumer inertia with regard to conservation, in industry and services as well as among householders.

The mismatch of the costs and benefits of energy efficiency measures undertaken in rented accommodation is a further obstacle. While tenants reap the benefits, landlords bear the costs. The recent North West Energy Study established that, for example, less than a third of local authorities had draughtproofed any proportion of their housing stock and only 8% had insulated hot-water tanks, both extremely cost-effective measures. (12)

Lack of finance for the more expensive energy efficiency measures also explains the non-adoption of many cost-effective techniques in industry, services and the home. Home insulation grants have served to ameliorate this problem in the past and the CEM companies are beginning to obviate some of the problems in the industrial and service sectors.

Finally, in the longer term, the Government's lack of commitment towards the future funding of the EEO does not bode well for the promotion of electricity conservation. Lower support will inevitably mean less information for consumers, less activity among industrial energy management groups and less leadership from Government itself.

A BALANCED ELECTRICITY POLICY

The present upheavals in the ESI provide a unique opportunity to correct the present imbalance in the efforts expended on electricity conservation and generation. The new electricity regulatory body, OFELEC, will be particularly well-placed to oversee the direction which private sector generators and distributors choose to take. However, much will depend on the legislative framework which the Government puts in place, on OFELEC's interpretation of its responsibilities, and on the licence conditions specified for the new private sector companies.

It would be naive to suppose that the promotion of energy conservation will be a major priority in the enormously

difficult task of privatising the ESI. However, there are many constructive steps which would be consistent with the Government's more central objectives. The menu of possible measures includes:

a) <u>Public sector leadership</u>. An example set by the Government in improving the efficiency of electricity use in the buildings which it itself owns and making similar requirements on local authorities could generate substantial savings and would raise the profile of electricity efficiency.

b) <u>Regulations and standards</u>. Existing regulatory devices, such as building standards, can be used to accelerate improvements in energy efficiency. Labelling requirements would give consumers more information about the widely varying costs of running major electric appliances. The results of a pilot labelling scheme initiated by the Eastern Electricity Board should be appraised carefully.

c) <u>Producer agreements</u>. Government could encourage manufacturers to reach voluntary industry agreements concerning standards of electricity consumption in different types of electrical appliances.

d) <u>Distribution company efficiency programmes</u>. Electricity distribution companies are better placed, in terms of both expertise and links to consumers, to promote efficient electricity use than any other body. The House of Commons Energy Committee has already recommended (13) that OFELEC should require the new distribution companies to prepare programmes designed to promote the efficient use of electricity. This might involve assisting consumers with conservation measures or negotiating with CEM companies the securing of identifiable reductions in electricity demand.

e) <u>Balance of supply and demand</u>. OFELEC could have powers to ensure that the risks of investing in excess generating capacity are borne by investors

rather than, as at present, by electricity consumers. This would ensure that a true commercial evaluation of investment in electricity generation would take place. Giving OFELEC the power to judge the prudence of investment proposals for electricity supply would be a more draconian, and perhaps politically less acceptable way of achieving the same objective.

f) Load management. Electricity distribution companies could be encouraged to investigate new possibilities for managing load at times of peak demand. At present, there are special contracts for larger consumers who agree to shed load at critical times during the winter. Ways of shedding domestic load, in freezers and water heating for example, could also be investigated. Electronic management systems (EMS) could be used by industrial and commercial users to shed load in response to more detailed time-of-day tariffs or load restrictions.

CONCLUSIONS

It is widely acknowledged that many cost-effective opportunities to use electricity more efficiently remain unutilised. These would, in addition, reduce the environmental impacts of electricity consumption. There are many obstacles to the proper operation of consumer markets for electricity and electrical equipment, while institutional biases give the ESI incentives to invest in new plant. If a greater emphasis on the rational use of energy is sought, electricity privatisation provides a unique opportunity to redress many of the institutional imbalances.

This paper began with the verdict that, in judging the title 'Conservation versus Generation', the offending word was 'versus' and that conservation and generation each have important roles to play in the balanced development of the ESI. This verdict stands, but I would like to add one concluding thought - if a balanced policy for the development of the ESI is to be prosecuted, a higher level of priority will need to be attached to the factors promoting and impeding the efficient use of electricity. Only in this

way can the Government defend the environment, and the best interests of the electricity consumer.

REFERENCES

(1) Privatising Electricity, Cm 322, HMSO, London, February 1988

(2) F P Jenkin, Proof of Evidence on the Need for Hinkley Point 'C', Hinkley Point 'C' Power Station Public Enquiry, CEGB 4, Central Electricity Generating Board, London, September 1988

(3) Central Electricity Generating Board, Annual Report and Accounts 1987/88, London, August 1988

(4) 'Climate Change and Sustainable Development: A messaage from Lord Caithness to the Toronto Conference June 1988', Appendix 4 of The Greenhouse Effect: Issues for policy Makers, Occasional Paper, Royal Institute for International Affairs/Policy Studies Institute Joint Energy Programme, London, October 1988

(5) Department of the Environment, Our Common Future: A Perspective by the UK on the Report of the World Commission on Environment and Development, London, July 1988

(6) World Commission on Environment and Development, Our Common Future, Oxford University Press, 1987

(7) March Consulting Group, Energy Study of the North West Region of the UK, 2 volumes, Manchester, December 1987 and Energy in Buildings, April 1988, p8

(8) See for example: March Consulting Group, op cit; Commission of the European Communities, Improving the Efficiency of Electricity Use, COM(87), 496 final, Brussels, October 1997; International Energy Agency, Energy Conservation in IEA Countries, OECD/IEA, Paris, 1987; G Leach et al, A Low Energy Strategy for the UK, Science Reviews,

London, 1979; D Olivier et al, Energy-Efficient Futures, Earth Resources Research, London, 1983

(9) Consumers' Association, Which?, various reports, 1986 - 88

(10) March Consulting Group, op cit.

(11) See for example, J F Skea, Electricity for Life: Choices for the Environment, Council for the Protection of Rural England/Friends of the Earth, London, October 1988

(12) March Consulting Group, op cit, Vol 2, p40

(13) House of Commons Energy Committee, The Structure, Regulation and Economic Consequences of Electricity Supply in the Private Sector. Third Report, Session 1987/88, HC 307-I, HMSO, London, July 1988, paragraphs 94 - 99.

Table 1
The CEGB's Capacity Need by the Year 2000 (GW)

Plant requirements 1988-2000	9.4
+ increased demand	7.0
+ increased reserve margin	1.2
+ planning uncertainty	3.5
= total capacity	21.1
- present surplus	9.3
= plant need	11.8

Source: derived from CEGB Proof of Evidence on the Need for Hinkley Point 'C'

Table 2
Institutional Factors Influencing Electricity Generation

Promoting	**Impeding**
industry ethos	siting difficulties
Pre-privatisation	high capital costs
low-cost, risk-free capital	
Post-privatisation	
promotion of competition	
non-fossil quota	
profitability of higher sales ('RPI-x')	

Table 3
Institutional Factors Influencing Electricity Efficiency

Promoting	**Impeding**
recognition of business opportunities	lack of information
environmental benefits	consumer inertia
	mismatch of costs/ benefits
	lack of finance
	run-down of government support

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THE ENVIRONMENTAL CONSEQUENCES OF UK POLICY

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Introduction

In essence, my message to the Conference can be put fairly succinctly. It is this:

At present, UK energy policy exists in no formally-embodied state. The last Energy Policy White Paper (1) was published in 1967, and the last Energy Policy Green Paper (2) in 1978 - both prepared by Labour Administrations.

This is not to argue that the three Conservative Governments since 1979 have operated entirely on an ad hoc basis, but it does mean, in my view, that there remains a danger of strategic loss of purpose in key energy policy decisions.

Thus, in the absence of an overview (and overhaul) of UK energy policy priorities, and of energy supply and demand trends to the year 2000 - though preferably forward to 2015 - it is all the more difficult for the Government to address the crucial and closely related policy issues of environmental impacts, energy efficiency, employment, the balance of payments and energy research and development.

Let me first review the major UK priorities and perceptions which have impinged upon UK energy policy over the past 20 years. Against this background, I will then address some of the crucial environmental issues which have emerged and which require integration into UK energy policy for the next two decades.

The Wider Energy Scene: The Energy Policy Rationale

Realities and perceptions in the energy field have proved remarkably volatile over the past 20 years - they are likely to remain so for the foreseeable future.

From the late 1950s, a low and stable world oil price and the greater ability of oil companies to control both the supply and price of oil persuaded planners that long-term oil supplies would be plentiful and cheap. Thus, the 1960s witnessed a massive expansion of international trade in oil, and high rates of economic growth, throughout the world, accompanied by very little concern about long-term global energy availability or the associated environmental impacts. During this halcyon period, energy policy planners were pre-occupied mainly with ensuring an 'optimal' supply mix to meet estimated future demand. Straight-line extrapolations of demand appeared to provide robust forecasts, and 'iron laws' of growth (eg electricity demand growth of 7 per cent per annum and oil demand growth at 8 per cent per annum) became commonplace.

Any errors which arose in forecasting demand could be made good, with relatively little disturbance to the balance of payments, by importing more or less oil. Oil was thus seen as the 'balancing' fuel: its costs were assumed to remain low and its future supply to be elastic. High growth in energy demand in the 1950s and 1960s reduced the risks of over-investment, because any excess supply capacity was soon absorbed by allowing demand to catch up. Energy efficiency was not on the policy agenda, although technological change and high investment led to steady improvements in energy utilisation. The declining incidence of smog from cities (following the 1956 Clean Air Act) and the 'tall stack' policy of the CEGB did much to remove the obvious and visual environmental impacts of air pollution.

In the 1970s, however, complacency gave way to acute concern, given the harsh realisation, following the first oil shock, that total global energy consumption had, over the previous two decades, been doubling approximately every 15 years and global oil consumption every 9 or 10 years. In addition, the industrialised nations realised that they, and the multinational oil companies, had lost control over the supply and price of oil. The oil producers, in a sellers' market, were now in charge of the exploitation of their own resources. These, and wider considerations, gave rise to the inconclusive 'Limits to Growth' debate and the growing strength of the environmental movement.

While the major uncertainties in the energy sector during the mid 1970s related primarily to the issues of adequacy of energy supplies, since the second oil 'shock' of 1979-80, more attention has been focussed upon the demand side.

In addition, after 1974 the 1960s set of conventional wisdoms (steady, high compound growth in demand at least for electricity and oil). were replaced by a new set. These were based upon the comforting assumption that world oil prices would continue a relatively smooth upwards trajectory - say 3-3.5 per cent per annum over the period 1980-2000 - perhaps doubling in real dollar terms by the end of the century.

The principal consequences stemming from this new conventional wisdom were that:

(i) total energy demand would, after allowing for broadly a 10 per cent reduction as a result of 'good housekeeping' measures, increase in line with GDP growth in the long term;

(ii) reduced consumption of oil would be achieved via enhanced energy efficiency and inter-fuel substitution, stimulated by rising real energy prices and widening fuel price differentials;

(iii) coal, natural gas and nuclear power would continue to expand their market shares at the expense of oil; principally coal and nuclear power in the large, 'crude heat', steam-raising markets in industry and power generation respectively; and natural gas and electricity in 'premium' markets such as the domestic and commercial sectors;

(iv) concern about the limited size of global oil and gas resources justified ambitious research and development (R&D) programmes in the 'flagship' technologies. including advanced reactor systems (fast reactors and fusion) and coal conversion (gasification and liquefaction) and, on a much smaller scale, on a number of 'wet and windy' renewable technologies (eg

wind, wave and tidal power); and

(v) the UK's oil import dependence would be reduced by the rapid exploitation of the UK Continental Shelf oil and gas resources.

Whilst, given the still dominant position of OPEC in the world energy market. uncertainties were not absent, this scheme appeared to be internally consistent, to be mirrored by the similar policy stances adopted by most other Western governments (and reinforced by the common objectives of the International Energy Agency and the European Economic Community), and to give each of the fuel industries a reasonably well-defined market niche. Other than for oil, the mood was one of expansionism, and competition between the fuels was seen to be less significant given continued growth in energy demand and their individual, somewhat different, market roles.

However, a series of inter-related factors have, especially over the past five years, changed the energy outlook radically. The substantive energy factors have included:

- repeated downwards revisions in economic growth and total estimated primary energy requirements in the UK and elsewhere - from, in some earlier projections, a doubling in total requirements to doubts as to whether even current demand levels will be maintained, certainly for oil and coal (see Table 1);

- the commissioning of substantial additional supply capacity in response to earlier decisions (eg non-OPEC oil) from the North Sea, Alaska and Mexico, expansion in Siberian gas output, widespread investment in low-cost coal, and expansion in nuclear generating capacity, especially in France and the USA);

- major reductions in demand for OPEC oil, belatedly reflected in the emergence of much lower prices for oil as market forces (aided by not inconsiderable unemployment) gained ascendancy over the cartel;

- significant closures of higher cost supply capacity -

power stations, refineries and mines - and contraction of the world tanker fleet; and

- cutbacks in long-term R&D expenditure, especially on the once much-vaunted 'flagship' technologies. (3)

These have been associated with other important, but qualitatively different, factors including:

- increased hesitancy on the part of analysts and decision-makers to commit themselves to long-term forecasts but, instead, to adopt shorter term horizons and to seek ways of maintaining flexibility against what is now perceived to be a much more uncertain future for the energy sector;

- particularly in the UK, the breakdown of the earlier political consensus about the role of public enterprise and hence an additional dimension of uncertainy relating to the consequences of 'privatising' BGC, the electricity and, if re-elected for a fourth term, the coal industries; and at the wider European level, uncertainty as to the structural realignments which may occur in the energy sector as a result of the Single European Market;

- a growing recognition that safety and environmental considerations, reinforced by the accidents at Three Mile Island, Sellafield and Chernobyl, and concern about acid rain deposition, the global greenhouse effect, land use planning pressures and nuclear waste disposal, may result in yet further politicisation of long lead time projects and constrain choices on the supply side of the energy equation.

The full consequences of these factors upon UK energy policy options can be discerned but dimly. However, in the short run at least, competitive forces have reasserted themselves in energy markets, the focus of decision making for the fuel industries has shifted from capacity expansion to cost control, profitability of all marginal energy investment is threatened with oil prices at $11/12 barrel, and consumers have regained, at least partially, the sovereignty assigned

them in elementary economics texts and in some recent Ministerial speeches.

However, just as the earlier conventional wisdoms were undermined by events, so can the present position. Political and military instability in the Middle East, and elsewhere in the world, continue to pose strategic threats to energy supply security at any moment. Any one of a series of factors could serve to destabilise the global energy supply/demand balance. The context for long-term energy policy is far from robust and a new consensus has yet to emerge. Nevertheless, leaving these uncertainties aside, it does appear that international energy markets will be more relaxed in the short term, offering the prospect of relatively low real increases in dollar energy prices.

Such an outlook justifies, to my mind, an urgent official re-appraisal of the UK energy supply and demand outlook to 2000 and beyond and especially of the implications of a return to large-scale energy imports and of the ways in which environmental issues may constrain energy policy choices. Such a re-appraisal is not necessarily synonymous with an energy policy statement. But I would personally favour an attempt at the latter, especially if its primary purpose was seen as an opportunity to identify <u>the scope for flexibility</u> against an uncertain global energy and environmental background, rather than a commitment to a rigid energy plan.

It is regrettable that the present UK Government sees no merit in assessing the possible evolution of Britain's energy demand and supply balance. As the IEA has observed: 'the UK stands alone among IEA countries in this approach. Other countries consider forecasts a valuable guide for planning for both the public and private sectors'. (4) The IEA recommended in the same document that the UK Government should:

(i) 'articulate as completely and explicitly as possible the goals and objectives of its energy policy, both generally and with respect to individual sectors, in order to provide a better understanding of government intentions among both domestic producers and

consumers of energy; and

(ii) consider whether regular projections of both supply as well as demand would be helpful to public and private decision-makers, not as targets or blueprints, but as a guide to planning.' (5)

Energy policy

All governments seem keen to distinguish themselves from their predecessors by the adoption of some set of readily identifiable 'buzzwords'. For the 1964-66 Wilson administration, the 'in' phrase was the 'white heat of the technological revolution'. Perhaps the present administration is best identified by the phrase 'stronger reliance on market forces'. While the role of market forces (which I take, in this context, to mean an increased role for private enterprise and reliance on the price mechanism) can never be under-estimated in the energy sector, there are important considerations which dictate the government's need to intervene to assist or reinforce such free market mechanisms.

Perhaps the most frequently-quoted, traditional definition of energy policy is that which appeared in the 1978 Green Paper on Energy Policy. It stated that:

> 'there should be adequate and secure energy supplies, that they should be efficiently used and that the two foregoing objectives should be achieved at the lowest practicable cost.' (6)

Such a bland definiton (and the massaging process involved in producing it) will, no doubt, be familiar to regular viewers of 'Yes Minister'! Like motherhood, it seems unobjectionable. Indeed, so all-embracing is it, that it could apply equally well to a policy for plastic buckets or door mats.

To be more serious, the decade since 1973 has convinced all of us that the energy sector is a commanding height of any modern economy, be it in the public or private sector. Not surprisingly, therefore, a very wide range of policy imperatives will concern the present administration, as they

have done its predecessors. They will need to be at the heart of the kind of policy review I am urging.

Stated briefly, these objectives include:

1. provision of low-cost supplies;

2. security of energy supplies;

3. price stability (overall and in fuel relativities) wherever possible;

4. balance of payments considerations;

5. employment, safety and welfare;

6. industrial policy questions relating to equipment supply;

7. environmental safeguards (eg oil pollution, lead in petrol, acid rain and nuclear waste disposal);

8. control over investment (especially within the remaining public sector fuel industries);

9. taxation policy (especially to capture economic rents in the North Sea);

10. R&D and technology choice, acquisition and transfer (especially for oil and nuclear power).

This list is far from complete. But it serves to highlight an important feature of the energy sector. That is, irrespective of the political completion of the government of the day, it is too important to be left to market forces alone. The capital intensity, the long investment time-scales on the supply side, the international and global dimensions (such as the IEA and EEC emergency oil-sharing commitments and the greenhouse effect) - indeed, the essential strategic considerations - dictate that this should be so.

The New Environmental Policy Agenda

The other major theme of my paper is the need to give far greater explicit attention to the environmental consequences of UK energy developments in such a policy review.

As a child of the 1940s, brought up in the road in Birmingham in which James Watt used to live, I was acutely aware of the environmental impacts of energy use - particularly the impenetrable and unhealthy winter smogs well described by Charles Dickens a century before.

The spread of Clean Air zones and the tall stack policy of the CEGB did much to remove the immediate and visual impacts of the environmental consequences. In addition, a combination of market forces (relative fuel prices), changing fuel availabilities, technological change, consumer preferences and government policy transformed the UK energy supply/demand balance.

In 1950, coal met 93 per cent of total UK energy requirements - in final markets (such as households, industry, local government buildings, the railways) and in the conversion industries - electricity and coal-based town gas.

While UK energy demand has risen by one-third since 1950, coal now meets only 33 per cent of total primary energy demand. Initially, coal lost market share to oil but, since the oil crises of 1973 and 1979, the share of oil has fallen from its peak of 48 per cent in 1972, to 35 per cent in 1987 - increasingly required for transport and petrochemical applications. Given the relatively small amount of hydro electric power capacity, and the slower than expected penetration of nuclear power, the contribution of primary electricity to total UK energy supplies is only 6 per cent.

The most dramatic change has been the penetration of natural gas, with a share of less than 1 per cent in 1967, rising rapidly to 25 per cent in 1987. To a large degree these changes in the UK fuel mix are at the heart of any assessment of environmental consequences. Major changes have also occurred in the relative significance of the different coal markets. In 1950, 80 per cent of coal was

used in final uses; now 75 per cent is used in power generation, 10 per cent in iron and steel, and a relatively small and declining share in houses and manufacturing industry.

Thus, increasingly, the environmental consequences of coal use relate to emission control in power stations and relatively few large industrial sites. The new EEC Directive on the control of emissions from Large Combustion Plants requires the UK to reduce its SO_2 emissions from existing plants by 20 per cent by 1993, 40 per cent by 1998 and 60 per cent by 2003 on 1980 levels and, on the same basis, NO_x emissions by 15 per cent by 1993 and 30 per cent by 1998. In addition, it is likely that the current EEC restrictions on gas use in power stations will be lifted and that gas will be used in both conventional steam and gas combined cycle units with further beneficial effects on NO_x and particularly on SO_2 emissions.

Similarly new exhaust emission standards will be placed on large, and subsequently on small, cars. From July 1988, oil refineries and both nuclear and fossil fuel power stations over 300 MWe output are on a list of projects requiring full, formal Environmental Impact Assessments covering project impacts on humans, wildlife, soil, water, air, landscape, material assets and the cultural heritage.

In addition the European Commission will shortly introduce a proposed Directive curbing emissions from medium-sized industrial boilers through the use of fuel product standards (maximum sulphur contents).

The 'Greenhouse Effect' poses perhaps the most challenging set of issues for the energy sector. The only real solutions are to reduce energy consumption through vigorous energy efficiency measures and/or to substitute fossil fuels with nuclear power and renewable energy sources. There are constraints on all of these routes. It is important to bear in mind that the UK now accounts for no more than 5 per cent of total global energy consumption and thus that solutions to the greenhouse effect would require a level of global agreement without precedent.

Conclusions

To conclude, it remains a matter of profound uncertainty whether, with current political philosophy, environmental and energy policy decision-making can be fused to produce flexible but robust policies. This is particularly the case in the UK given the current overwhelming emphasis placed upon the efficacy of the market mechanism as a prime mover. As we know, markets think short term, yet the adjustment of energy supply and demand balances in ways which will serve to reduce environmental impacts will take decades.

Privatisation and relatively weak regulation of the successor companies appear likely to reduce the scope for interventions by Government to reconcile sometimes conflicting energy and environmental priorities. More effective policy fusion, and an in-depth review and overhaul of UK energy policy, thus appear to be pre-requisites for environmentally robust energy decision-making.

REFERENCES

1. Fuel Policy, Ministry of Fuel and Power, HMSO, London, Cmnd 3438, November 1967.

2. Energy Policy - A Consultative Document, HMSO, London, Cmnd 7101, February 1978.

3. For views on longer term energy R&D and technology policy see: Energy Research Development and Demonstration in the UK, House of Commons Select Committee on Energy, Ninth Report, Session 1983-84, HMSO, London, HC 585-I, July 1984; and J H Chesshire, Energy Forecasting: Some Lessons for UK Technology Policy, Papers in Science, Technology and Public Policy, No 5, London, November 1983.

4. Energy Policies and Programmes of IEA Countries - 1984 Review, IEA/OECD, Paris, 1985, p 492.

5. Ibid, p495.

6. op cit, p 3, para 2.1.

A Comparison of UK Energy Demand Forecasts for the Year 20000

Year of Forecast	Author of Forecast	Actual Primary Energy Demand in Year of	Forecast Primary Energy Demand in 2000 (mtce)
1976	WAES (1)	330	490–610
1976	ACORD/Dept Energy (2)	330	420–760
1977	Dept Energy (3)	338	500–650
1978	Dept Energy (4)	340	450–560
1978	Chesshire/Surrey (5)	340	335–577
1979	Leach (6)	356	330–361
1979	Dept Energy (7)	356	445–510
1980	WOCOL (8)	329	360–450
1982	Dept Energy (9)	312	328–461
1982	CEGB (10)	312	258–418

Note: mtce = million tonnes of coal equivalent

Sources:

1. Workshop on Alternative Energy Strategies, Energy Demand Studies: Major Consuming Countries, MIT, Cambridge, MA, 1976

2. Department of Energy, Advisory Council on Research and Development (ACORD), Energy R&D in the United Kingdom, a Discussion Document, June 1976

3. Department of Energy, Energy Policy Review, Energy paper 22, HMSO, 1977

4. Energy Policy: A Consultative Document, Cmnd. 7101, HMSO, February 1978

5. J H Chesshire & A J Surrey, Estimating UK Energy Demand for the Year 2000: A Sectoral Approach, SPRU Occasional Paper No. 5, University of Sussex, February 1978

6. G. Leach et al, A Low Energy Strategy for the United Kingdom, International Institute for the Environment ande Development, Science Reviews, 1979

7. Department of Energy, Energy Projections 1979, A Paper by the Department of Energy

8. World Coal Study, Future Coal Prospects, Ballinger, cambridge, MA, 1979

9. Department of Energy, Proof of Evidence for the Sizewell B Public Enquiry, October 1982

10. CEGB, Statement of Case, Volume 1, Sizewell B Power Station Public Enquiry, April 1982

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SESSION 3

INDUSTRIAL POLLUTION CONTROL

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INDUSTRIAL AIR POLLUTION LEGISLATION IMPLEMENTING THE EUROPEAN FRAMEWORK

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1. THE SIGNIFICANCE OF EEC ENVIRONMENTAL LEGISLATION

The growing impact of EEC environmental policies on Member States of the community is now well recognised. From a legal perspective, the effect has been particularly significant in the United Kingdom since our pollution laws have traditionally concentrated on providing mechanisms of control, but have largely been silent on precise goals or standards to be attained (1). In many areas (most notably air and water pollution) EEC legislation now provides explicit and quantitative criteria upon which control decisions must be based. The scientific basis and rationale behind the numerate standards contained in certain Directives is, to say the least, questionable, and the drafting of provisions is often ambiguous, using a free-flowing linguistic style unfamiliar to those used to dealing with the text of British statutes and regulations (2).

Environmental policy making in Britain was no doubt somewhat less complicated before 1973, but whatever criticisms one may have of both the process and contents of EEC legislation, it now represents a substantive body of law in this field. Around 60 Directives concerning pollution have been made in the last fifteen years - quite an achievement simply in terms of administrative productivity given that the Commission's Directorate-General XI, dealing with environment, consumer protection and nuclear safety only has a staff of around 150. Following the Single European Act 1986, the amendments to the Treaty of Rome now provide for the first time an explicit remit for environmental policy in the body of the Treaty itself (3). It is a development of both legal and symbolic significance which will ensure that the EEC will continue to be a potent source of policy in this field. This does not necessarily mean that one will see another 60 pollution Directives in the next fifteen years. The indications are that more attention will be paid to ironing out technical deficiencies in existing Directives, and ensuring that they are implemented in practice as well as theory within Member States (4). This shift of emphasis will be welcomed by many, but does not in any way lessen the

continuing importance and impact of EEC legislation; on the contrary its effects may be felt more sharply.

The rest of this paper is divided into a number of sections. In the next section, I review 6 key existing EEC Directives which have an impact on the control of industrial air pollution in this country - the whole field of vehicle emissions, though the subject of much EEC legislation is excluded. In Annex I the full range of industrial directives is listed. As far as possible, I have tried to avoid simply reproducing in precis form the terms of the Directives (5). And I have deliberately refrained from discussing how they have been implemented in this country, and the extent to which present national measures do or do not meet the requirements of the Directives. This information is readily available elsewhere (6). Instead, I have drawn attention to particular provisions which from a lawyer's eye, at least, - and looking at them without preconceptions - raise issues of potential significance. Section 3 deals with the likely future agenda for EEC air pollution policies. The final section discusses developing European case-law on the important issue of implementation of Directives.

2. EEC DIRECTIVES CONCERNING INDUSTRIAL AIR POLLUTION

The Directives below are grouped under general policy headings rather than presented chronologically, and are of relevance to the control of air emissions from industrial installations.

2.1 AIR QUALITY STANDARDS

There is a family of three Directives concerning general air quality standards, with Member States being given a broad discretion as to the means to achieve them. Clearly, industry may only be indirectly affected by their implementation, since it may not necessarily be the principal source of emissions likely to breach the relevant standards.

(a) <u>**Council Directive of 15 July 1980 (80/779/EEC) : Sulphur Dioxide and Suspended Particulates**</u>

Annex I of the Directive contains a table of numerate air quality standards (described as 'Limit Values') relating to sulphur dioxide and suspended particulates. Under Art 3 each Member State must take 'appropriate measures' to ensure that these limit values are met throughout its country by 1st April 1983 with the possibility of derogations in particular zones up to 1st April 1993 by the latest.

The requirement to achieve the Limit Values (primarily based on the protection of human health) by the specified dates represents the most explicit legal obligation under the Directive and has therefore been the one to which most immediate attention has been given. But the Directive is more than just about establishing the Limit Values, and contains other obligations and policy mechanisms. Three should be noted:

- Where the level of existing pollution by SO_2 and suspended particulates are low in comparison with the Limit Values, the implementation of the Directive "must not bring about a significant deterioration in the quality of the air (Art 9). The effect is almost to require a stand-still of existing levels below the Limit Values (thus penalising those countries with high air quality?), though the use of the term 'significant' (a favourite adjective in many EEC Directives and one not defined) allows for a degree of relaxation.

Haigh has noted (7) that Council Minutes (not published in the Directive) declared that this was not to be interpreted as prohibiting the siting of new plants that may be a source of smoke or SO_2 in such areas.

The British circular implementing the Directive (Clean Air DOE Circular 11/81) misleadingly describes this qualification as stated in the Directive itself (para 29). The European Court has held that observations of the Council cannot give rise to an interpretation that results in something different from the actual terms of the Directive (8) - the true legal position appears to be that such development may be permitted provided its effect on existing air quality levels is

not 'significant', and this does not necessarily mean that it is permissible to allow development to raise existing levels up to the Limit Values.

- Annex II of the Directive contains further numerical limits described as Guide Values, considerably stricter than the Limit Values and including daily mean values over a 24 hour period. In contrast to the Limit Values, the Guide Values are set to serve as long-term precautions for the environment as well as human health (see Preamble to the Directive). No time-limits are prescribed for reaching these Values, but under Art 6 Member States "shall...endeavour to move towards them".

- Under Art 4 Member States may establish two types of protection zone. Under the first, established where it is felt necessary to limit or prevent a forseeable increase in pollution in the wake of development, Member States may fix values lower than the Limit Values, taking the Guide Values as a reference point. The obligations under the second type, established in localities which the State considers should be afforded 'special environmental protection' give less room for discretion - in such zones, Member States 'shall fix values which are generally lower' than the Guide Values.

The provisions described above are expressed in more qualitative and less direct terms than the duty to achieve the Limit Values, making it difficult for the Commission to consider formal infraction proceedings - indeed, there is no legal obligation on Member States to establish Art 4 Zones. But it would be a mistake to think that they can therefore be ignored. The Directive requires the Commission to publish every year a summary report on how the Directive is being applied throughout the Community. Should there be no apparent progress on these aspects of the Directive, one could expect to see pressure from the Commission for action to be taken. The justification for doing so would be all the stronger if some Member States are seen to be acting upon them (setting up protection Zones, moving towards Guideline Values etc.,) and others doing little. Similarly, since these 'subsidiary' provisions are focused more on environmental protection rather than public health, pressure for their implementation will be reinforced with increasing scientific

evidence of damage to the natural environment by these substances.

(b) <u>Council Directive of 3 December 1982 (82/884/EEC) on a Limit Value for Lead in the Air</u>

The Directive lays down a single air quality standard for lead in the air expressed as 2 microgram Pb/m^3 on an annual mean concentration, and is based on the need to protect public health.

The standard had to be met by 9 December 1986, though Art 3 provides that the Commission must be informed of places where this limit may be exceeded; in such cases Member States must forward plans for the progressive improvement of air quality with the aim of meeting the standard by 9 December 1989 at the latest.

As with the previous Directive, Member States have a wide discretion as to how to achieve the standard since they are required simply to 'take the necessary measures' to do so. And again there is a quasi-standstill provision since any measures adopted must not result in a 'significant deterioration' of existing air quality where current levels are below the 2 microgram standard.

(c) <u>Council Directive of 7 March 1985 (85/203/EEC) on an Air Quality Standard for Nitrogen Dioxide</u>

The Directive follows more closely the pattern of the SO_2 Directive by prescribing both Limit Values and stricter Guide Values, though the provisions contain some important legal differences. The preamble states that there is insufficient technical and scientific information available to lay down standards to protect the environment generally, and the Limit Value (200mg/m^3 on a 98th percentile basis over a year on a mean value per hour) is therefore set primarily to protect public health, though it is intended that this will indirectly contribute towards environmental protection.

The Limit Value had to be met by 1st July 1987, though as with the previous Directive, Member States must inform the Commission of zones where this is likely to be exceeded,

together with improvement plans to ensure compliance by 1st January 1994 at the latest. In addition to the general legal obligations to reach the standard, there is an additional procedural check on breaches, as the Directive requires that from 1987 Member States inform the Commission of instances where the Limit Value has been exceeded, and of measures proposed to deal with them.

As with the SO_2 Directive, the Guide Values (135mg/m^3 on a 98th percentile basis on mean values per hour over the year and 50mg/m^3 of 50th percentile basis) are intended to contribute towards the protection of the environment as well as public health. But in contrast to the SO_2 Directive, Member States are under no general duty to endeavour to move towards them. Instead they only come into play if Member States decide to establish zones under Art 4 where special environmental protection is considered necessary - in such zones Member States 'may' fix limits less than the Guide Values (lower values are not obligatory as for the SO_2 environmental protection zones).

In common with the other two Directives, application of the Directive must not lead to significant deterioration of existing air quality already below the prescribed standard. Under Art 5 Member States are also given an express general power to lay down at any time values more stringent than those contained in the Directive, even outside special zones. Such a general power is not provided in the other Directives. This provision seems all the more striking since it is contained in the only one of the three Directives to derive its legal base in part from Article 100 of the Treaty of Rome (rather than the 'catch-all' Article 235) on the basis that "discrepancies in Member States with regard to nitrogen dioxide could give rise to unequal conditions of competition and thereby directly affect the functioning of the common market". Stricter standards developed at a later date for some but not all areas within the EEC could, on that argument, lead to a distortion of the market - though maybe it is acceptable if it results from self-imposed measures which disfavour the country making them.

2.2 EMISSION CONTROLS ON INDUSTRIAL PLANT

(a) Council Directive of 28 June 1984 (84/360/EEC) on combating of air pollution from industrial plant

The Directive, which had to be implemented by 30 June 1987, applies to 19 broad classes of industrial plant listed in Annex 1. The main aim of the Directive is to ensure that there is a common form of prior authorisation of such plants to be operated after 1987 throughout Member States, and the Directive does not itself prescribe any numerate emission limits. For that reason, it is tempting to view it as a framework Directive which lacks real bite until 'daughter' Directives are made. There is some truth in that view, but various provisions do, however, contain a number of important principles of pollution control which are now applicable to such plants, and which are of potential significance.

The Directive applies different regimes to 'existing plants' (essentially those in operation or authorised before 1 July 1987) and to those commencing activities after that date. There are, however, some possible areas of ambiguity in the distinction (which has critical implications) which I will discuss at the end of the section.

REQUIREMENTS FOR POST-1987 PLANTS

For post-1987 plants, there must be an authorisation procedure, and applications and the results of decisions must be publicly available. Authorities may only issue an authorisation if they are satisfied that the four following principles are satisfied (Art 4):

(i) All 'appropriate preventive measures' against air pollution have been taken, including the application of the 'best available technology' provided that such measures do not entail 'excessive costs'. These criteria are clearly rich in open-textured language involving complex judgements of the type familiar to the Alkali Inspectorate and its successor bodies. It should be noted that 'air pollution' receives a broad definition in the Directive referring to the introduction of substances or energy likely to harm human health, living

resources and ecosystems, property, or the interference with amenities or other legitimate uses of the environment. An authority's legal remit is therefore not limited to specified gases or substances, nor is it restricted to public health considerations, and must include potential damage to flora and fauna, as well as general nuisance considerations.

(ii) The use of the plant will not cause 'significant' air pollution from any of 8 substances listed in Annex II - described as a list of 'Most Important Polluting Substances', and including sulphur dioxide, oxides of nitrogen, dust and chlorine. Although (as we might expect) 'significant' is not defined, in legal terms this requirement is quite distinct from that in (i) above, and is not qualified by the use of best available technology not involving excessive costs. The implication is that providing significant pollution from these substances is likely to occur, the authority is not entitled to grant an authorisation - even if the operator is proposing the best practicable means to limit the pollution or cannot afford further abatement equipment sufficient to make the pollution 'insignificant'.

(iii) No applicable emission limits will be exceeded. Art 8 allows for emission limits to be fixed by the Council in subsequent Directives, and the recently agreed Large Combustion Plant Directive, discussed below contains such emission limits. Emission Limits prescribed under Art 8 must be based on the best available technology not entailing excessive costs, and the Council must act unanimously. However, the drafting of the Directive does not require that the emission limits relevant to the authorisation have to be derived from those made under the Art 8 procedures. Legally (though not necessarily politically) it might be possible in future for a Directive to be made under Art 100 of the Treaty (which since the Single European Act requires only majority voting) specifying emission limits which would then be applicable to authorisations under this present Directive.

(iv) The applicable air quality limit values "will be taken into account". In contrast to the position with emission limit values, the Directive itself provides no explicit powers to prescribe air quality limit values, and it must be presumed that the provision is referring to Directives such as those

described in 2.1 (SO_2, NO_x, etc.), and any others that may be made at later dates.

Stricter principles concerning post-1987 plants can apply in two cases, one discretionary and one obligatory:

First, under Art 5 a Member State may define special protection areas where it may fix more stringent emission or air quality limit values.

Secondly, Art 12 aims to prevent initial authorisations becoming fossilised and outdated. Member States are obliged to follow developments regarding both the best available technology and the environmental situation, and in the light of this, they must, if 'necessary', impose conditions on authorised plants, bearing in mind the desirability of 'avoiding excessive costs for the plant in question, having regard in particular to the economic situation of the plants belonging to the category concerned.' This complex sentence appears to mean that while the financial circumstances of the particular plant in question is highly relevant, it must be set against the general economic health of the type of industry concerned; e.g. if, say, other cement manufacturers are able to invest in further abatement equipment, the extra requirements should apply to a single plant, even if this places the operator in financial difficulty.

REQUIREMENTS FOR EXISTING PLANT

No authorisation procedures are required for existing plants falling within the specified classes, and, on a strict reading the emission limit values developed under Art 8 would not be applicable to such plants. Art 12 contains the sole requirements relating to existing plant: Member States are obliged, in the light of developments in best available technology and the environmental situation, to implement "policies and strategies, including appropriate measures" for the gradual adaptation of existing plant to the best available technology.

In implementing such an adaptation programme, Member States must take into account the technical characteristics of the plant, its operating life, the nature and volume of

emissions from, and the desirability of not entailing excessive costs for the plant, having regard to the economic situation of undertakings belonging to the category in question.

On the face of it, the general duty of Member States under Art 12 to implement policies and strategies aimed at the gradual adaptation of existing plants to the best available technology is applicable to every single existing plant falling within Annex I. But there are doubts as to its precise implications. The current programme of retrofitting existing coal-fired stations - while meeting recently agreed EEC policies under the Large Combustion Plant Directive concerning the overall reduction of national SO_2 figures - is selective in its application and does not apply to every existing power station. It could be argued that this policy does not therefore necessarily fulfil the duty under Art 12. The possibility of gradual adaption must be considered for every plant.

THE DISTINCTION BETWEEN EXISTING PLANT AND POST-1987 PLANT

The implications of the Directive for existing and post-1987 plant are quite different. Yet the terms of the Directive are not very precise on the distinction, despite its importance, and I want to draw attention to some possible ambiguities.

- 'Existing plant' is defined in the Directive to mean a plant 'in operation before 1 July 1987 or built or authorised before that date'. The Directive does not specify what 'authorised' means in this context - supposing outline planning permission had been granted for a factory before 1987 but not yet built and not yet registered with HMIP (if a scheduled process) - is that an 'authorised' (and therefore 'existing') plant or not?

- The Directive does not actually use a term for 'Post-1987' plant, and it seems that one must assume that the authorisation requirements apply to plants which are not 'existing' within the terms of Directive - i.e. the Article 4 requirements concerning prior authorisation etc, apply to plants in operation after July 1987 or built or authorised after that date. This is reasonably clear where the control system envisages a single authorisation. But where the

controls are based on the requirement of annual registration (as under the Alkali Act), does each registration amount to an 'authorisation'? This might imply that (a) the Art 4 requirements must be applied each year to Post-1987 plant when it comes up for authorisation and (b) that where such annual authorisation procedures apply, it means that even Pre-1987 plant is not in fact authorised at the end of the year and is therefore subject to an authorisation to which the Art 4 requirements apply (this latter interpretation is one which in fact even the most ingenious lawyer might have difficulty sustaining).

- Under Art 3 a 'substantial alteration' of plants falling within Annex I requires an authorisation. It is not clear whether this is confined to alterations only of post 1987 plants, or whether it would be applicable to an alteration of an existing plant. Nor is the term 'substantial alteration' defined. Presumably, in the context of the Directive, it would include any alteration that significantly affects the emissions from the plant, and is not confined to the type of alteration that would, in the UK context, require planning permission.

(b) <u>EEC Directive concerning Large Combustion Plants 1988</u>

The authorised text of this Directive, agreed in June of this year, after 55 months of negotiation, had not been published at the time of writing this paper, and this section contains only an approximate summary.

The Directive has sometimes been described as the first of the 'daughter' Directives to the Industrial Plant Directive outlined above. It contains emissions limits for certain types of plants (and to that extent derives in part from that Directive) but it does far more than that, and to describe it as a 'daughter' is misleading. Certainly the Commission does not view it as such, but as a distinct air pollution Directive in its own right.

The Directive contains two main distinct, though related, types of requirement.

National Emission Reductions: Reduction targets for national emission from large combustion plant are specified. For the UK, the figures are, using 1980 as a starting point.:

SO_2	20% by 1993	NO_x	15% by 1993
	40% by 1998		30% by 1998
	60% by 2003		

Member States may apply to the Commission to request that the reduction figures or deadlines be altered where due to unexpected changes they are unlikely to be met. While the Commission is obliged to accede to the request, the issue may be referred by another Member State to the Council for a final decision by majority vote.

Emission Limits for New Plant: The Directive specifies emission limits relating to SO_2 and NO_x for new plant with boilers larger than 100MW. There is a provision for some relaxation of the SO_2 standards where the plant burns high sulphur indigenous coal, and the possibility of a year's derogation for NO_x standards. These limits are subject to revision by the Commission. In 1990, the Commission must make proposals for emission standards for plant within the 50MW and 100MW range.

(c) **Directive of 27 June 1985 on the Assessment of the Effects of Certain Public and Private Projects on the Environment (85/337/EEC)**

The Directive introduces a number of procedural requirements which aim to ensure that the environmental effects of certain types of proposed developments are taken into account before they are permitted to proceed. The Directive does not oblige authorities to refuse to authorise development which is likely to have a harmful impact on the environment - simply to take these matters into consideration. The required procedure involves preparation of environmental information by developers, public consultation, consultation with other relevant authorities - all these steps combine to amount to the 'assessment'.

From 27 June of this year, the procedures must be followed for 9 broad classes of development listed in Annex I of the

Directive, a number of which are likely to give rise to potential air pollution (e.g. oil refineries, thermal power stations, integrated chemical installations and asbestos related installations). The much larger number of specified classes in Annex II need only follow the assessment procedure if they are likely to have a 'significant' impact on the environment.

In the United Kingdom, many of the types of development specified would normally require planning permission, and therefore regulations have been made designed to incorporate the requirements of the Directive into development control procedures - Town and Country Planning (Assessment of Environment Effects) Regulations 1988. These are complex, running to 19 pages, and rather than attempt a summary, I will highlight certain matters of particular relevance to air pollution.

(i) For a development falling within the requirements, the information that the developer must provide (called an 'Environmental Statement' in the British regulations) must, as a minimum, include a description of likely significant effects, direct and indirect, including its possible impact on air plus (and this is potentially important) the interaction between its impact on air and other possible impacts (including, e.g. flora and fauna, soil, water, and the cultural heritage).

(ii) If significant adverse impacts on the air are identified, the developer's statement must include a description of measures planned to 'avoid, reduce or remedy those effects' (Reg 2(1) and Sched. 3 of the regulations).

(iii) The developer's statement MAY include further information concerning, inter alia, estimations of air emissions resulting from the operation of the development, likely effects on the environment (including secondary, cumulative, and short and long-term) and forecasting methods employed.

(iv) The planning authority may require in writing that the developer supplies the information mentioned in (iii) if he has not done so; elaborate any information on those points which he has supplied already; or produce such evidence as may be

reasonable to verify information in the statement. Failure to comply with such requests does not appear to invalidate the planning application itself though may jeopardise its chances of success.

(v) Where the application relates to a scheduled process under Sch. 1 of the Health and Executive (Emissions to the Atmosphere) Regs. and involves a mining operation, manufacturing industry or disposal of waste, a developer preparing an environmental statement is entitled to call upon the assistance of Her Majesty's Pollution Inspectorate. HMIP is under a legal duty to enter into consultation with the developer to find out if it possesses relevant information and if they have they must make such information available to him (unless it is confidential). These duties apply only if the developer has indicated to the planning authority that he intends to submit an environmental statement with his application; where his application relates to an Annex II development and he needs advice on whether it is likely to have a significant impact or not (thus determining whether an environmental statement is required or not), there are no legal duties on HMIP to assist.

In respect of any development requiring an Environmental Statement, this 'duty to assist' also applies to other bodies which must be consulted under the provisions of the General Development Order, together with the Nature Conservancy Council, the Countryside Commission, and the County Council (if not the planning authority).

(vi) The statutory bodies mentioned above are entitled to make comments on the application and final statement before the planning authority makes its decision.

(vii) Planning permission may not be granted unless the authority has first taken into consideration the environmental statement submitted by the developer, any representations by bodies entitled to be consulted or the general public which relate to the environment effects of the proposal.

For those types of development falling within the terms of the Directive, one of the important implications of the new

requirements is that pollution issues relating to proposals in effect become a mandatory material consideration for planning authorities. The legal position under existing Town and Country Planning legislation is that this was almost certainly the case anyway, though the situation is now considerably more formalised. But 'taking into consideration' is an elusive requirement - and neither present planning law nor the Directive itself has much to say on the quality of decisions eventually reached.

3. THE FUTURE AGENDA

On the imediate horizon, draft EEC legislation has been published concerning new and existing municipal waste incinerators (COM (88) 71); and the implementation within the EEC of the Ozone Convention, aimed at reducing the manufacture and use of chlorofluorocarbons.

The Fourth EEC Action Programme on the Environment (1987 - 1992), drafted by the Commission, and approved in general by the Council of Ministers on 19 October 1987 provides as good a guide as any on the most likely areas of development over the next five years. As with many future strategy documents, it probably errs on the side of ambition. Unexpected events may upset existing policy programmes, and the fact that an item is included in the Programme does not mean that political agreement will be forthcoming. On this latter point, though, the Resolution of the Council of Ministers lists a number of priority areas to be pursued, and these at least can be taken to reflect some degree of political consensus.

Both the Programme and the Council Resolution emphasise, inter alia, the importance of the implementation of EEC legislation, improving the scientific basis of environmental policy, and increasing access to information on the environment.

(i) Air Pollution

According to the Council Resolution, under the general heading of pollution prevention, the priorities in the field of air pollution should be:

> " effective implementation of existing Council Directives on air quality and air pollution from industrial plants and ... adopting and implementing measures concerning emissions from large combustion plants and motor vehicles".

The text of the Programme itself includes a number of policy aims, which are of particular relevance to industrial emissions. These include:

- pursuance of a strategy of requiring a substantial overall decrease of emissions of acidifying substances in the air from all major sources; sulphur, nitrogen oxides, hydrocarbons and photochemical oxidants receive special mention.

- identification of both indoor and outdoor atmospheric pollutants of greatest concern from both human health and environmental perspectives.

- setting of Community-wide objectives for substantial reduction of total emissions from all relevant sources in the air to combat acid deposition and associated damage.

- longer-term reduction of ambient air concentration of most important pollutants to protect sensitive eco-systems.

- implementation of preventative measures against indoor air pollution.

- development of an inventory of major sources and emissions, and of best available technologies and their associated costs.

- possible development of emission standards for types of industrial plant not covered by the Large Combustion Plant Directive - nuclear installations and installations burning fuel oil and solid fuel are mentioned.

- development of further air quality standards for particular pollutants, with photochemical oxidants a high priority. Community ecological air quality standards are also mentioned.

(ii) Pollution Transfer

The issue of 'Best Practicable Environmental Option' has received high profile in this country in recent years. The term is not mentioned as such in the 4th Programme, but the Council Resolution stresses that Community action must take account of the need to,

> " prevent the transfer of pollution from one part of the environment to another"

In the Programme itself, the air pollution objectives state that in determining the most appropriate means for dealing with pollution problems, care must be taken that,

> " air pollution is not simply transferred to water or soil" (4.1.6.)

Furthermore, a whole section is devoted to discussing the question of multi-media pollution controls generally. It is accepted that with the exception of the Directives concerning environmental assessment and the notification and testing of new toxic substances, most EEC pollution controls have been based on single medium approaches. The text of the discussion indicates three approaches that may be adopted in the future - these are not necessarily mutually exclusive.

(i) Equalize Standards (the crudest strategy) - Make sure that controls in one medium are not tighter than those in another, which would otherwise encourage possible transfer. The conclusion in the Programme is that the Community 'needs to move to increasingly strict environmental standards in all sectors.' (3.2.3)

(ii) Substance-Orientated Approach. It is concluded that as yet, 'there has been no coherent attempt within the Community to assess substances on a cross-media basis or to devise control strategies on such a basis.' (3.5.2). The approach would be to assess the occurrence of a particular chemical, and conduct an 'integrated risk-assessment' leading

to a choice of the most effective and efficient options for its management. The Commission's 1985 proposals concerning asbestos and its review of cadmium provide a pointer for this approach. The likely first step would be to identify a list of priority substances - examples specified are PCBs, cadmium, lead, phosphates, arsenic, copper, mercury, asbestos and dioxins. (3.3)

(iii) Source-Orientated Approach. If appropriate, focus controls on individual classes or groups of industries and covering all potential discharges into whatever medium. This is not a new policy approach, but was foreshadowed in the First Environment Action Programme, following which fifteen key industrial sectors were identified for possible action. But it is noted that apart from the example of the Titanium Oxide Directive and the aborted draft Directive concerning the paper and pulp industry, no further progress has been made in this regard. The discussion emphasises the need to develop full emission inventories as a first step, and to undertake further studies and discussion. Acknowledgement of the difficulties already experienced is made, and though a case is made for powerful unified control authorities within Member States if such an approach is to be properly implemented, the tone of the discussion is fairly cautious.

4. IMPLEMENTATION OF DIRECTIVES - FORMS AND METHODS

The European Court of Justice is the final legal guardian of the Treaty. It is independent of both the Council and Commission, and its judgements and development of legal principles are of crucial importance to an understanding of the full implications of EEC Policy developments (9). In this final section I want to discuss a developing area of case-law which has an important bearing on the future shape of EEC and national environmental law.

All of the EEC laws concerning air pollution described in Part 2 have been in the form of Directives - that is, legal obligations on Member States to ensure that they have in place the necessary legal and administrative machinery to fulfil the objectives of a particular Directive. It is clear that the whole question of implementation of EEC

environmental laws within Member States generally will be an issue of high priority over the next decade, and an initial important problem area is the method chosen by a Member State to implement a particular Directive. In this context the critical legal question concerns the extent to which each country has a discretion to adopt whatever means (formal laws, administrative circulars, etc.) it feels most appropriate to achieve those goals.

A literal reading of the text of EEC laws appears to give an unfettered discretion, provided the aims of the Directive are met. Article 189 of the Treaty of Rome provides that, 'A Directive shall be binding as to the result to be achieved upon each Member State to which it should be addressed but shall leave to the national authorities the choice and form of methods'. Furthermore, most Directives conclude with a provision such as, 'Member States shall bring into force the laws, regulations, and administrative provisions necessary to comply with this Directive'.

Since 1982, however, in a series of cases the European Court has developed principles which suggest the discretion of Member States is more limited that might appear at first glance. As a result of the cases so far, there is a temptation to conclude that mandatory requirements in environmental Directives relating, say, to Environmental Quality Objectives or Emission Standards, can no longer be implemented into national policies and controls by means of 'quasi-law' such as circulars but must be given formal legal expression in regulations or primary legislation. This may well be the preferred policy of the Commission, and accords with current trends in national pollution policy developments, but a closer examination of the existing case law shows that the legal position is by no means so settled.

The issues appear to have been first raised in EC v Belgium (1982) 2 CMLR 622, concerning type-approval requirements under Motor Vehicles and Tractors Regulations. The court held that the Belgian Government's method of implementing the Directive by administrative methods was inadequate, and stressed the need for legal certainty and clarity in the implementation of the Directive. In EC v Italy (1984) 1 CMLR 148, concerning a Directive relating to the marketing

and labelling of medicinal products, the Commission challenged the Italian Government's claim that it had effectively implemented the Directive by means of Ministerial Circular and Order (a Bill had been in preparation but had been lost due to dissolution of the Italian Parliament). The Court upheld the Commission's claim with a key statement of principle:

> " Mere administrative practices which by their nature may be altered at the whim of the authorities and lack the appropriate publicity cannot be regarded as a valid fulfillment of the obligation imposed by Art. 189 of the Treaty".

The only case in this series which concerned an environmental Directive was EC v Kingdom of the Netherlands (1982 ECR 1791). This related to the Bathing Water Directive (76/160/EEC). The Dutch Government had argued that no national legislation on the subject was necessary because supervision of water quality was carried out in a framework of a decentralized system, regional and local authorities were bound by the terms of the Directive, and in any event the full text of the Directive had been included as an Annex to the current multi-ennial programmes. The Court held that this was insufficient to implement the Directive. While Member States were free to delegate powers to their domestic authorities, this did not relieve it from the obligation to give effect to the Directive 'by means of national provisions of a binding nature'. Advocate General Capotorti in his Opinion to the Court stressed that, unless existing legislation was 'already in perfect harmony with the provisions of the Directive', the State must adopt national legislation incorporating the mandatory content of the provisions of the Directive, so that the latter may apply uniformly throughout the national territory'.

The principles developed by the Court thus seem fairly clear. But apart from the fact that there were serious doubts whether in fact the administrative means employed did actually meet all the aims of Directives concerned, a critical element of all these three cases is that the Directives concerned were all based, wholly or in part, on Article 100

of the Treaty of Rome. This Article aims to approximate and harmonize provisions in laws, regulations and administrative action which would otherwise distort competition and have a direct effect on the functioning of the common market. This seems to me to have been a significant factor which led the Court to the conclusions it reached. As AG Reischl put it the key case of EC Commission v Italy.

> " The aim of harmonisation can only be achieved if Directives are turned into provisions of national laws which have the same legal force as those governing the same subject matter in other member states." (my emphasis).

Some of the existing environmental Directives mentioned in Part II of this paper were indeed based wholly or in part on Article 100 (e.g. those concerning SO_2, NO_x and Industrial Plant, as too are those concerning vehicle emissions). But others were not (e.g. lead in the air, environmental assessment), and these derived their authority from the 'catch-all' Article 235 of the Treaty, Directives under Article 235 are not aimed at harmonising national provisions which would otherwise distort competition, and since there is no judgement of the European Court dealing with the method of implementing a Directive based on Article 235 alone, it is not safe to assume that it would necessarily follow the reasoning in the case-law above.

One of the most recent cases concerning the implementation of a Directive is significant in that the Directive concerned was not based on Article 100 and it thus takes us a little way further. EC v Germany (1986) 3 CMLR 579 arose out of the German Government's implementation of Nursing Directives based on Articles 52-58 in the Treaty concerned with the free movement of workers and the right of establishment in the Community. The German Government was in the process of preparing national legislation directly relating to the obligations under the Directive as part of a general package of reforms, but in the meantime, and in order to meet the EEC deadlines, the administration was interpreting broadly drafted provisions in existing national laws in order to give effect to the requirements under the

Directive. The Court was not satisfied that this amounted to a proper implementation of the Directive, and was not convinced by the argument of the German Government that a principle of German public law (Selbstverbindung per Verwaltung) would have prevented administrators from taking decisions which departed from their established practice.

The Court, however, noted that it followed from Article 189 of the Treaty that the implementation of a Directive does not necessarily require legislative action in each Member State. General principles of constitutional and administration may render implementation by specific legislation superfluous, 'provided, however, that those principles guarantee that the national authority will in fact apply the Directive fully'. It also appears to have been particularly important in this case that the Directive concerned individual rights. Professionals from other countries must be able to ascertain their legal position. Proper implementation of such a Directive, therefore requires that the legal position is 'sufficiently clear and precise and the persons concerned are made fully aware of their rights and where appropriate afforded an opportunity of relying upon them before the national courts'.

The issue of implementation of environmental directives is one that can be expected to come up again before the European Court within the next few years. The question is all the more complex and interesting because of the amendments to the Treaty since the Single European Act. Before then EEC Environmental Directives were based either on Article 100 of the Treaty (harmonization to avoid distortion of competition) or Article 235 (catch-all) or both. The rationale for invoking Article 100 was, I think, dubious in some cases, but it gave the appearance of firmer legal authority. Now there is the further option to base future environmental Directives on the basis of the new Article 130 which specifically relates to environmental policies. Article 100 remains (and as amended also refers to environmental protection). Directives made under Article 235 must be agreed by unanimous voting by the Council of Ministers (unless it agrees that certain matters may be decided by majority voting), while those under Article 100 can now be agreed by a majority. In the future, on those voting

distinctions alone, there are likely to be strong political pressures for basing a particular Directive on either Article 130 or Article 100 (10); and one can expect the correct legal basis of such Directives will be an issue that will reach the European Court (11).

In the meantime, the principles so far developed by the Court on the question of implementation suggest that:

(1) A Directive based on Article 100 requires to be implemented by means of national legislation

(ii) A Directive which creates individual rights should generally be implemented by legislation, or at least the legal position for those individuals should be absolutely clear and precise

(iii) Whether any environmental Directives can be said to create such individual rights is a legal question as yet unexplored

(iv) Where a Directive has been based on Article 235 or the new Article 130 it is less certain whether its mandatory provisions must be implemented by means of legislation. However, it seems that a Member State should be able to guarantee that it has bound itself and appropriate national authorities to apply the Directive fully. This latter principle may in practice mean that legislation is necessary, but the circle has not yet been drawn.

The cases that have reached the Court so far have been largely concerned with the formal methods of implementing of Directives. As the introduction suggested, in future years the concern of the Commission is likely to shift more to the actual practical implementation of the obligations under environmental Directives in Member States. To date, this is an area where little in the way of principles of European law have been developed by the Court. They need to be - and I have no doubt that they will before too long.

Notes and references

(1) See Macrory R (1987) 'Environmental Law and policy in the United Kingdom' in Enyedi et al (ed) Environmental Policies East and West, Taylor Graham, London

(2) One of the best and most accessible accounts of the difference in drafting style between British and European legislation remains Lord Denning's classic judgement in Bulmer v Bollinger SA (1974) 4 Ch 401 at 411

(3) See new Article 130 R, 130S, and 130T in the Treaty of Rome

(4) See in particular Resolution of the Council of Ministers of 19 October 1987 concerning the continuation and implementation of the Fourth Action Programme on the environment (1987-1992) (87/C328/01). The preamble states that the Council 'Underlines the particular importance it attaches to the implementation of the Community legislation'. On the subject of the need to review the design of existing Directives, see especially the evidence of S Johnson (European Commission DG X1) to House of Lords Select Committee on the European Communities Fourth Environmental Action Programme, 8th Report Session 1986/7, at 185 and 186

(5) The full texts of existing Directives are contained in Garner Control of Pollution Encyclopaedia, Butterworths, London

(6) The most complete and lucid account is Haigh N (1987) EEC Environmental Policy and Britain, Longmans, London

(7) ibid. at p. 183

(8) Case 429/85 Commission of the European Communities v Italian Republic (23 February 1988). The case concerned the failure to implement fully Article 8 of the Directive 79/831 on classification, packaging and labelling of dangerous substances. The Italian Government prayed in aid a statement of the Council of Ministers recorded in the minutes at the meeting at which the Directive was approved

but the Court held that 'It must be observed that an interpretation based on a statement of the Council cannot give rise to an interpretation different from that which results from the actual terms of Article 8 of the Directive.' In the case of the SO_2 Directive, the qualification was apparently approved by the Commission as well as the Council, and this may make the issue unlikely to come before the courts

(9) See Slynn G (1983) 'The Role of the European Court' in Macrory R (ed) Britain, Europe and the Environment, Imperial College Centre for Environmental Technology, London

(10) See 'A Change of Rules for the EEC's Environmental Policy' ENDS Report 145 February 1987 9-11

(11) One of the key issues in the recent judgement of the European Court in Case 68/86 United Kingdom v Council of the European Communities (23 February 1988) was whether Directive 85/649 on the use of hormones in livestock farming should have been based on Article 43 (agriculture) (requiring a qualified majority) or Article 100 (harmonisation) (then requiring unanimous voting). The Court held that the Directive was correctly based since Article 38 of the Treaty gave precedence to specific provisions in the agricultural field over general provisions relating to the establishment of the common market.

ANNEX

EEC Legislation relevant to Industrial Air Pollution

Air Quality Standards

Sulphur Dioxide and Suspended Particulates	80/779
Lead	82/884
Nitrogen dioxide	85/203

Controls over Plant Emissions

Industrial Plant	84/360
Assessment of Environmental Effects of Certain Public and Private Projects	85/337
Large Combustion Plant	88/

Products and Substances

Sulphur content of gas oil	75/716
Chlorofluorocarbons (Council Decisions)	80/372 & 82/795
Asbestos	87/217

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HM INSPECTORATE OF POLLUTION
A PROGRESS REPORT

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Origins

1. HM Inspectorate of Pollution (HMIP) was established on 1 April 1987. It brought together:

HM Industrial Air Pollution Inspectorate (IAPI)
HM Radiochemical Inspectorate (RCI)
the Hazardous Waste Inspectorate (HWI)
a new water inspection function.

2. The case for a unified Inspectorate was first made in the Fifth Report of the Royal Commission on Environmental Pollution (1976), which drew attention to the way in which pollution can be transferred between media, and argued that it made little sense to look at single aspects of control in isolation. The Commission proposed that a unified pollution inspectorate should be set up to ensure an integrated approach to difficult pollution problems at source; it should, they suggested,expand the concept of best practicable means (BPM) to ensure the adoption of the best practicable environmental option (BPEO).

3. An Efficiency Scrutiny carried out in 1986 also concluded that the progressive integration of the four inspectorates in HMIP would over time provide value for money benefits both from improved administrative co-ordination and from the enhanced capacity of the field force to balance a wider range of environmental, technological and financial considerations.

Aims and Objectives

4. The initial aims and objectives of HMIP were:

Aims and Objectives	Explanations
To exercise efficiently and effectively statutory powers for controlling radioactive substances, emissions to air from scheduled processes, and Water Authority discharges to water.	The continued exercise of the existing powers of HMIP for the direct control of pollution - a first order function.
To monitor the efficiency and effectiveness with which Water and Waste Disposal Authorities exercise their powers of control;and to secure improvements where appropriate.	Monitoring the exercise of pollution control functions where these belong to pollution control authorities outside central Government - a second order function.
To ensure the development of economically sound technicalpractices for disposing of waste in the most environmentally acceptable way.	Continuing work on the development and dissemnination of best practice (as seen, for example, in the now well established series of Waste Management Papers).
To work with policy Directorates in developing the concept of BPEO, and feasible methods of applying the cross-media approach to pollution control.	More innovative work on the development of the cross-media approach and on the practical application of the elusive concept of BPEO.
To develop as an authoritative and independent source of advice on pollution control practices.	Reflects on objective set for HMIP by Ministers in the light of the efficiency scrutiny.

To develop plans for implementing the Government's strategy for radioactive waste management (pending a decision on the location of this work in the longer term).	Self-explanatory.

5. Thus HMIP does not simply enforce a given set of rules. It interprets and enforces the BPM requirement; develops and promulgates sound technical practices; develops technical policy; and in the case of radioactive waste is responsible for the complete range of policy and technical issues.

Methodologies of Pollution Control

6. HMIP inherited pollution control systems with significantly different methodologies, particularly as regards quality objectives (QOs), the principle of 'as low as reasonably achievable' (ALARA), and the use of BPM. Thus:

> the control of emissions to air has for many years been based primarily on BPM, with relatively little recourse to QOs except in the determination of chimney heights;
>
> for the control of radioactive discharges we historically relied on the ALARA principle, more recently supplemented by BPM, within a framework of dose limitation which can be regarded as a specific and peculiar type of QO;
>
> discharges to water have traditionally been controlled with primary regard to QOs, with little use of BPM;
>
> None of these special concepts has been systematically applied to the disposal of hazardous waste.

Developments since April 1987

(a) Air

7. New arrangements for air pollution control were first

described in the consultation paper issued by DOE, the Scottish Development Department, and the Welsh Office in December 1986. This review - the first comprehensive reappraisal of air pollution policy for thirty years - was prompted in part by the Royal Commission's Fifth Report, and in part by other pressures, in particular the increasing involvement of the European Community in environmental matters. It recognised that local authorities needed new powers to control a middle range of industrial processes, which did not warrant central control because they were neither potentially gross polluters not technologically difficult to control, but which could nevertheless give rise to significant local pollution. The consultation paper therefore proposed a more certain and cost-effective control system for these industries than is available under the current mix of Clean Air Acts and the Public Health Acts Powers, which normally force the Local Authority to wait for a nuisance to develop before it can act to remedy it. The Government also wished to provide an open and more publicly visible system of control.

8. The proposed mechanism is an extended list of scheduled processes which split into a Part 'A' and Part 'B'. Part 'A' processes will generally be the larger and technically complex operations to be regulated by the central Inspectorates. Part 'B' processes will tend to be smaller, more numerous and less complex, to be regulated by Local Authorities, with Environmental Health Officers exercising the same prior approval and enforcement roles for Part 'B' processes as HMIP Inspectors exercise now for scheduled processes.

9. The objective of providing a more transparent system will be met by the use of publicly available authorisations for all scheduled processes. In the light of the comments made about the December 1986 consultation paper, which was generally well received, it has been decided to make authorisations legally binding documents. Such authorisations will contain the main air pollution control requirements for the process, describing the essential features of the equipment and methods to be used to control air pollution, including all the emission limits applicable. The authorisation will contain a residual duty to operate the

process and carry out all other functions not specified in the consent in accordance with best practicable means. Such authorisations will be held on publicly available registers at the offices of the Inspectorates and Local Authorities. To ensure consistency of policy and practice across the central and local enforcement sectors of the new system an Inspectorate/Local Authority Standing Liaison Committee will be set up. This Committee will not be a statutory body but is expected to have an influential steering role. The task of more detailed monitoring of the new arrangements, the preparation of notes on best practicable means for Part 'B' processes, and the production of central guidance for the Local Authority sector will be handled by a new 'Local Authority Unit' to be set up in HMIP. This Unit will be staffed by an HMIP Inspector and an Environmental Health Officer with support staff. The system of publicly available authorisations will also make an important contribution to consistency of enforcement practice and the application of national guidelines.

10. The first stage in the introduction of these new measures will be regulations to extend the schedule administered by the Inspectorate and to provide the public with more information about the planned controls when any plant is newly authorised. A second consultation paper will be published setting out in detail the process descriptions for the new two-part schedule. Further measures will then be needed to introduce binding authorisations and to set up the new two-tiered air pollution control regime by national Inspectorates and Local Authorities.

(b) Water

11. HMIP started with three water inspectors. By the end of 1987 their number had risen to eleven. The main task of the Water Branch has been to investigate the reasons why a large number of sewage treatment works have failed to comply with their consent conditions. In the light of their report a programme has been established for securing full compliance by 1991, and guidelines announced for enforcement.

12. Shortly after HMIP was established the Government

announced new proposals for the reorganisation of the water indsutry, including the establishment of a National Rivers Authority (NRA), which will become the main pollution control authority for regulating industrial discharges to water. Subject to the passage of appropriate legislation, the NRA is likely to be set up in mid 1989.

13. In November 1987 the Government announced new proposals for strengthening controls over the inputs of the most dangerous substances to water. A limited range of the most dangerous substannces will be identified in a 'Red List', and processes discharging a significant amount of them will be scheduled for control through the progressive application of technology-based emission standards, based on the concept of best available technology not entailing excessive costs (BATNEEC). HMIP will have a major role to play in this control system, together with the NRA. Detailed proposals have been set out in a consultation paper published in July.

(c) Radioactive Substances

14. The main issue in radioactive waste management is the selection of a deep site for the disposal of low level and intermediate level waste, following the Government's announcement on 1 May 1987 that no further work would be done on the four sites previously shortlisted for the shallow burial of low level waste. The Government is awaiting proposals from UK Nirex.

15. Progress has been made in the programme of authorisations for the discharge of radioactive waste to water and air. New authorisations for atmospheric discharges from Sellafield, Heysham and Torness have been issued; these now incorporate maximum limits, subsidiary limits at which notification has to be given to the regulatory Departments, and a general BPM requirement.

(d) Other Wastes

16. HMIP exercises indirect influence rather than direct control over the operations of landfill sites, whether privately or publicly owned. A third report from the former Hazardous Waste Inspectorate has confirmed that there

continue to be wide variations in the standards of waste disposal management, with some operations inadequately controlled.

17. In addition to its programme of site visits, this branch of HMIP exerts its influence through the dissemination of best practice. A major Waste Management Paper (WMP) on Landfilling Wastes was published in 1986; HMIP are now giving priority to a revision of the basic WMP on site licensing, and to the preparation of a new WMP on landfill gas.

Towards Integrated Pollution Control (IPC)

18. The initial Action Plan for HMIP made it clear that legislation would be needed in due course to give statutory form to HMIP.

19. During its first year HMIP has carried out two case studies in association with the management of two major industrial plants, to examine the feasibility of a more integrated system of pollution control, with regard to waste reduction technology, emissions to air and water, and the disposal of the residual solid waste. The results of this work are being incorporated in a programme of selected joint inspections of suitable processes and have been taken into account in a detailed consultation paper on Integrated Pollution Control, published in July 1988. These proposals would give HMIP systematic control over:

a. processes in Part A of the December 1986 Air Pollution Consultation paper;

b. processes discharging Red List substances to water in significant quantities;

c. processes generating large amounts of special wastes.

20. Legislation is unlikely to be introduced before 1989/90, but meanwhile HMIP will be preparing for IPC by moving to a regional structure, with integrated but specialised teams of inspectors, from April 1989.

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SESSION 4

AIR POLLUTION CONTROL SITUATIONS REPORT - PART I

Chairman
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TRENDS IN AIR POLLUTION FROM THE REFINING AND USE OF PETROLEUM PRODUCTS

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Structure of Paper

Today I want to outline the changes in the petroleum products market which have occurred between 1973 and 1987 and how these developments have affected the emission levels of pollutants. Because of the decline in total demand and the change in product pattern, many refineries have been shut down and those remaining have been modernised and upgraded. The types of crude oils processed have also changed with the development of the North Sea fields. I will describe the effect of these process changes on refinery emissions of sulphur dioxide and the increasing recovery of elemental sulphur.

I propose also to put current refinery emissions of sulphur dioxide, nitrogen oxides and hydrocarbons into the context of total UK emissions. It is appropriate that we also look at emissions generated by the use of petroleum products as fuels in the hands of our customers, including the effects of the progressive reductions of lead in petrol and the transition to unleaded petrol which has now begun, and how sulphur dioxide emissions from heating oils have declined.

Finally, against a background of likely market and legislative developments, I will explore future trends in air emissions associated with the oil sector.

Changes in Petroleum Demand Pattern Between 1973 and 1987

In the two decades before 1973 there was a steadily expanding market for petroleum products based on a crude oil price which was below $2/Barrel. Consumption increased annually and reached 100 million tonnes in 1973. Most of the crude oil came from the Middle East and 70% was of high sulphur content. Total UK SO_2 emissions were 5.8 million tonnes with refineries, which are large fuel users, accounting for 6% of the national burden.

Figure 1 shows the product split. In 1973 Light ends, mainly butane, propane and chemical feedstocks were 11%; Petrol was 17%; Kerosine 7% - about half used for aviation jet fuel

and half as burning kerosine. Gas oil sales were about 20% with an average sulphur content of 0.6% and Fuel Oil, with an average of 2.8% sulphur, accounted for 40% of the total barrel. Special Products, the remaining 5%, are mainly bitumen, lubricating oils and waxes.

The dramatic increase in oil price in 1973 and the further rise in 1979/80 as a result of the revolution in Iran resulted in a large reduction in the total market demand for oil products. By 1987 demand was 68 million tonnes with a crude oil price of around $14-15/Barrel, with low sulphur North Sea crude constituting 70% of refinery feedstocks. Total UK sulphur dioxide emissions were 3.7 million tonnes, down 36% from the 1973 level - qualifying the UK for a '36% Club' perhaps. Refinery emissions of sulphur dioxide fell faster than the national average and in 1987 were just over 3% of the national burden.

The sharp reduction in the total demand for oil products has been accompanied by a remarkable shift in the pattern of product demand. Fuel oil demand has shrunk to a quarter of the 1973 figure and now accounts for only 15% of the barrel; fuel oil has been replaced to a large extent in power generation and heavy industry by coal, gas and nuclear fuels. The average sulphur content of fuel oil is 2.2%.

While the fuel oil market has declined, demand for transport fuels has increased. Petrol now constitutes 33% of the product split, while the aviation fuel market has doubled and accounts for over three quarters of kerosine sales. Diesel sales have also doubled and now account for half of gas oil sales. The average sulphur content of gas oil has been more than halved at 0.25% in 1987.

Refinery Closure Programme

In 1973 there were 22 refineries with a total primary distillation capacity of 142 million tonnes per annum (Figure 2). The buoyant market, which had been growing at more than 5% per annum for over 20 years, encouraged expectations of continuing growth; in 1973 there were 3 new refineries at the planning stage in addition to expansion proposals at existing refineries. The abrupt change in the oil

supply equation and the emergence of OPEC resulted in the large increase in crude oil price and a major change in oil economics.

Oil demand fell because of competition from cheaper alternative sources, because oil was a traditional energy source for heavy industries themselves facing shrinking demand for their products and because of improvement in the efficient use of fuel. This last was stimulated by the perception of an energy crisis which focussed on the finite nature of fossil fuels - especially oil.

Faced with a major surplus in primary distillation capacity, oil companies embarked on major refinery rationalisation programmes. In the UK, this has meant the closure of 9 refineries leaving just 11 by end 1987 plus 2 small specialist bitumen refineries (Figure 3). The industry now has a primary capacity of 90 million tonnes per annum.

Ironically at the same time that 40% was being removed from the UK refining capacity, the industry was having to invest heavily in secondary processing plant. This was needed to correct the imbalance in the product split. The principal need was to convert unwanted heavy fuel oil into petrol and motor diesel fuel. In 1973 most refineries had a relatively simple configuration as shown in Figure 4. Crude oil was distilled to separate the crude oil into raw products for further treatment and blending. Secondary processing was largely confined to working up product qualities: catalytic reforming to meet octane requirements of petrol, hydro-treating to stabilise kerosine, particularly for jet fuels, and hydro-desulphurisation to remove sulphur from gas oils with recovered elemental sulphur as a byproduct.

By 1987 refining had become highly complex by the addition of new processes and extension of existing ones (Figure 5). Catalytic cracking is the major new process for upgrading fuel oil to light ends, petrol and gas oil. Vacuum distillation is the feedstock preparation process for catalytic cracking. More light ends gas is used for refinery fuel and for alkylation to produce petrol. Reforming capacity has been greatly increased to produce high octane petrol to blend with other lower octane streams and to offset the progressive loss

of octane provided by lead alkyls. Hydro-desulphurisation processing and sulphur recover capacity has also been greatly extended to treat gas oils produced by catalytic cracking which have much higher sulphur contents than those produced by straight distillation.

Sulphur Balance

These developments in the market and in the technology of oil processing have produced major changes in the sulphur balance across the whole oil sector. First the total amount of sulphur entering UK refineries has reduced from over 2 million tonnes in 1973 to around 1 million tonnes. One third of this reduction is simply the result of the reduction in crude throughput while the remaining two thirds is the result of greater use of low sulphur feedstocks from the North Sea.

Secondly, the increased secondary conversion of fuel oil has produced more low sulphur gas for use as refinery fuel. This has had a positive overall effect on refinery sulphur dioxide emission reduction by displacing some high sulphur fuel oil. Thirdly, sulphur recovery in refineries has tripled in tonnage terms in spite of the crude input changes. Figure 6 compares the tonnage of sulphur byproduct produced in 1973 and 1986. It also shows the cumulative effect of all these factors on the sulphur dioxide emissions from UK refineries which fell by around 60% between 1973 and 1986. These changes have been gradual and continuous over the period; Figure 7 shows the evolution. Since 1973 refinery emissions of sulphur dioxide per tonne of crude oil processed have fallen by more than half.

Refineries' Contribution to Total UK Emissions

It is important to review the contribution of the refinery sector to the total national pollution and I propose to look in turn at the three main categories of gaseous emissions: sulphur dioxide, nitrogen oxides and hydrocarbons.

Sulphur dioxide: Figure 8 shows that over the period total UK emissions of sulphur dioxide decreased from 5.8 to 3.7 million tonnes. All four sectors have reduced emissions, though 'Power Stations' still account

for 70% of the total, a fact which emphasises why they are still the prime target for future improvements in sulphur dioxide controls. The 'Domestic' sector, which includes commercial transport and agriculture, has halved; this reflects the shift to gas for space heating and the introduction of fuel specifications with lower maximum sulphur contents.

The largest change has been in the 'Industrial' classification where the reduction to one third of the 1973 level reflects the major switch away from relatively high sulphur content fuel oils in favour of cleaner fuels such as gas or electricity. The reduction also shows the influence of the decline of certain heavy industrial sectors.

The contribution of sulphur dioxide from 'Refineries' as we have already seen also declined to about one third. In 1973 refineries accounted for 6% of the UK burden. By 1986 it was down to close to 3%. Incidentally, it should not be assumed that the national sulphur dioxide emission patterns of all countries are similar. In the UK production from refineries is more or less in balance with inland demand. In the Netherlands, a substantial net exporter of petroleum products, and with a very different profile of primary energy sources compared with the UK, refinery sulphur dioxide emissions contribute nearly 25% of the national emission load.

Nitrogen Oxides: Over the past 15 years total UK emissions of nitrogen oxides, expressed as nitrogen dioxide equivalent, have been between 1.8 and 2.0 million tonnes. The recent concern about low level ozone formed by photo-chemical reaction between oxides of nitrogen and hydrocarbons in the atmosphere and ozone's involvement in acidic deposition and damage to vegetation, has sharply focussed attention in both the precursor reactants. Figure 9 shows the profile of UK NO_x emissions. 'Transport' and 'Power Stations' contribute 42% and 41% respectively and, with the growth of the UK vehicle inventory, NO_x emissions from tail pipe exhausts have been tending to

increase. 'Industry', 9% in 1986, on the other hand, has been emitting less NO_x. 'Domestic' emissions are static and currently account for 6%.

Oil refineries, like the rest of industry, have been steadily reducing their contribution to NO_x emissions. They currently account for 2% of the total. Oil companies, like other intensive energy users in manufacturing industry, have followed policies of installing low NO_x burners in new furnaces and when overhauling existing units. However, the main targets for achieving significant national reductions are power stations and transport.

Hydrocarbon emissions: Man-made hydrocarbon emissions, the other component in the formation of the secondary pollutant ozone, have also remained around 2.0 million tonnes per annum but are rising as a result of the increasing number of cars on the roads. Figure 10 shows the contribution made by each sector in 1986. The two major sources are first, solvent evaporation from adhesives and paints, and secondly, evaporative emissions and exhaust gases from vehicles. Refineries, including stack and evaporative storage losses, only account for 2% of the UK total. A further 5% arises from the distribution of petroleum products - mainly petrol, as it progresses through the terminals to filling stations and into vehicle tanks. This problem of hydrocarbon emissions control is now being looked at by the European Commission and, within a few years, is likely to extend the current controls on vehicle exhaust emission to cover evaporative emissions from vehicles and distribution terminals.

Emissions Related to Product Quality

Two specific aspects of air pollution relating to the use, rather than the manufacture, of petroleum products are the issue of lead in petrol and sulphur emissions derived from petroleum fuels. Both are important in the context of air quality.

Lead Emissions from Petrol: Lead alkyls were first added to petrol to improve octane quality in the late 1920s. Lead contributed to the development of efficient, high compression ratio engines and, by providing high temperature valve seat lubrication, reduced the cost of mass produced cars where the valve seat is cut directly into soft cast iron engine blocks. In 1967 the first control on lead content was applied in the first British Standard on petrol which specified a maximum level of 0.84 grammes/litre. This was an indication of the early concerns about the increasing quantity of lead being released to the environment.

As the volume of petrol sold increased, concern about health implications - initially unfocussed - resulted in a series of reductions in the maximum permissible level of lead in petrol. Figure 11 shows the progressively lower levels. The early reductions were by voluntary agreement between the oil industry and Government and aimed to keep the total lead emission level at about that existing in the early 1970s around 7,300 tonnes. Later the reductions were by Government regulation and then by EEC Directive.

Figure 11 shows that the progressive ratcheting down of permissible lead levels was successful in holding down the national lead burden more or less constant in spite of the fact that over the period 1973 to 1985 petrol consumption increased by around 30%. At each stage octane levels were maintained by the oil refining industry replacing octane lost by lead reductions by introducing more severe refining processes.

In 1983 the Royal Commission on Environmental Pollution concluded that the safety margin between actual lead levels and those likely to damage health was too narrow. Although conclusive evidence connecting petrol lead with neurological impairment was lacking, the removal of lead from petrol was deemed to be the most effective and practical way of reducing the lead burden in the air.

So we are now at the beginning of the transition to unleaded petrol and the EEC Directive requires that Member Countries ensure that there is 'availability and balanced distribution' by October 1989. The number of filling stations selling

unleaded petrol is increasing rapidly and by the end of 1988 one in four refuellings was expected to take place in stations where the motorist has a choice between leaded and unleaded. About 50% of vehicles in the inventory can use unleaded, over 2 million without adjustment and another 7 million with minor retuning. Thanks to the Chancellor giving a lower duty rate to unleaded, it is cheaper at the pump than either grade of leaded but so far motorists' response has been disappointing.

In all other countries the introduction of unleaded has been primarily a step taken to pave the way for universal application of catalytic converters on vehicles: a means of reducing, not only lead emissions, but the full spectrum of polluting gases which emerge from the tail pipes of vehicles. The absence of catalysts makes it more difficult to persuade people to change their refuelling habits.

In 1973 lead emissions peaked at 8,400 tonnes. In 1986, with all petrol in the UK being of low-lead quality at 0.15g/l maximum, the lead burden was 2,900 tonnes. The rate at which further reduction takes place is in the short term a function of how fast the public changes over to unleaded petrol. In the longer term it is likely to be a function of when mandatory catalysts are required in new cars.

Sulphur Emissions from Petroleum Products Used as Fuels: During the last 15 years the emission level of sulphur dioxide from the use of petroleum products in heating fuels and propulsion fuels has decreased. This has been partly due to reduced consumption and partly to reduction of the sulphur contents of products. Figure 12 shows how the annual emission load has evolved.

Although there has been some reduction in specified maximum sulphur levels in some products - like gas oils where maximum sulphur has progressively moved to 0.5% in 1981 and, in January 1989. to 0.3% - in general the lower product sulphur contents have been volunteered by the oil companies. Over the period, for example, the average sulphur content of heavy fuel oil has been reduced from 2.8% to 2.2% without legislation and gas oil has already been below 0.3% for five years.

The peak on the curve in 1984/85 is the effect of the surge in fuel oil consumption at the time of the miners strike; it is a volume effect, not a product quality aberration.

Summary of Refinery and Product Use Emissions

The table below summarises the position in 1986 so far as emissions from refineries and from product use are concerned. The 13 refineries are comparatively small contributors to the total UK burdens.

1986 Contribution to UK Emissions
from Refineries and Petroleum Products

	Refineries		Product Use as Fuels	
	10^3te	% of Total UK	10^3te	% of Total UK
SO_2	116*	3%	660	17%
NO_x	38	2%	930	48%
HC	41	2%	680	33%

Sources: Department of the Environment's 1987 Digest of Environmental Statistics except * which is from HM Industrial Air Pollution Inspectorate Report for 1987.

On the product use side, heavy fuel oil use constitutes the greater part of the sulphur dioxide emitted. Of the 48%

NO_x, 42% comes from vehicles exhausts. The 33% hydrocarbon load is made up of 28% from vehicle evaporative and exhaust emissions and 5% from evaporative losses from the petrol distribution system.

Future

Finally, I should like to look forward to the year 2000 against the trends since 1973 and the current position. Figure 13 shows one possible scenario for 2000, which is at the optimistic end of the range, giving a demand of 65 million tonnes; a pessimistic approach would be around 45 million tonnes. This estimate shows continued expansion of demand for transport fuels, with petrol up to 36% and diesel demand moving gas oil demand to 30%. In contrast fuel oil is projected as continuing to fall to about 6%.

All these trends will quantitatively reduce sulphur dioxide emissions from product use. In addition by 2000 both gas oil and motor diesel are likely to be at a maximum sulphur level of 0.2% or lower. It is also likely that by then fuel oil sulphur content will be tightened on an EEC basis quite possibly with a 2% maximum on all grades and a 1% sulphur maximum for special uses. The European Commission had indicated its intention to give the Small Combustion Plant Directive high priority and it is likely this proposed legislation will be the main means of implementing further control of sulphur dioxide emissions. These pressures, coinciding with a decline in low sulphur North Sea crude supplies, will necessitate substantial investment in additional desulphurisation plants and hydrogen generation facilities.

The Large Combustion Plant Directive lays down strict limits for sulphur dioxide and NO_x emissions from new plant. As a result refinery emissions will continue to fall as plant renewals and new projects are required to accommodate changes in product specifications referred to above and comply with the emission limits applicable to new plants.

It is certain that emissions from refineries and the use of petroleum products will continue to be reduced over the next decade.

FIGURE 1

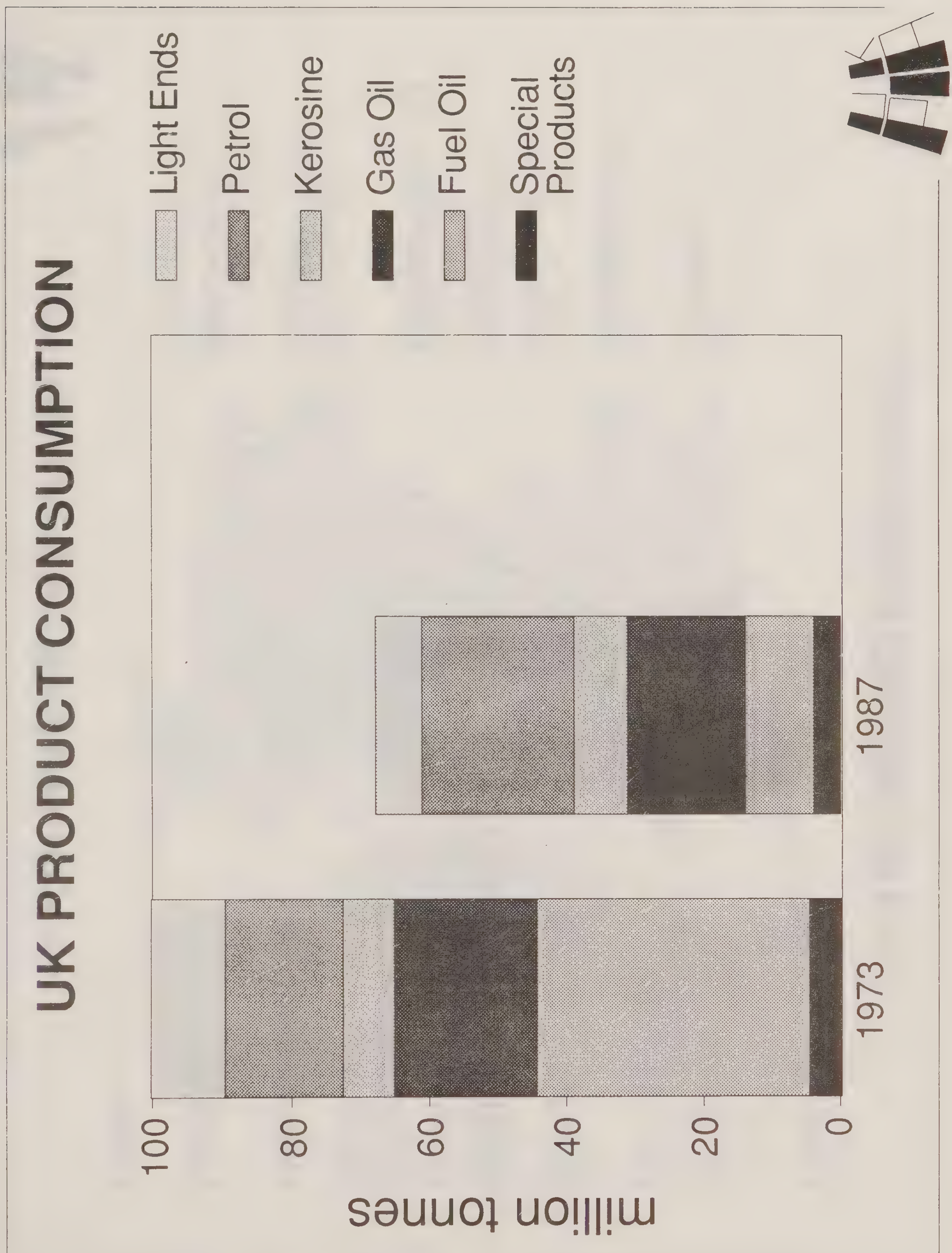

UK PRODUCT CONSUMPTION
Light Ends
Petrol
Kerosine
Gas Oil
Fuel Oil
Special Products
million tonnes
100
80
60
40
20
0
1973
1987

FIGURE 2

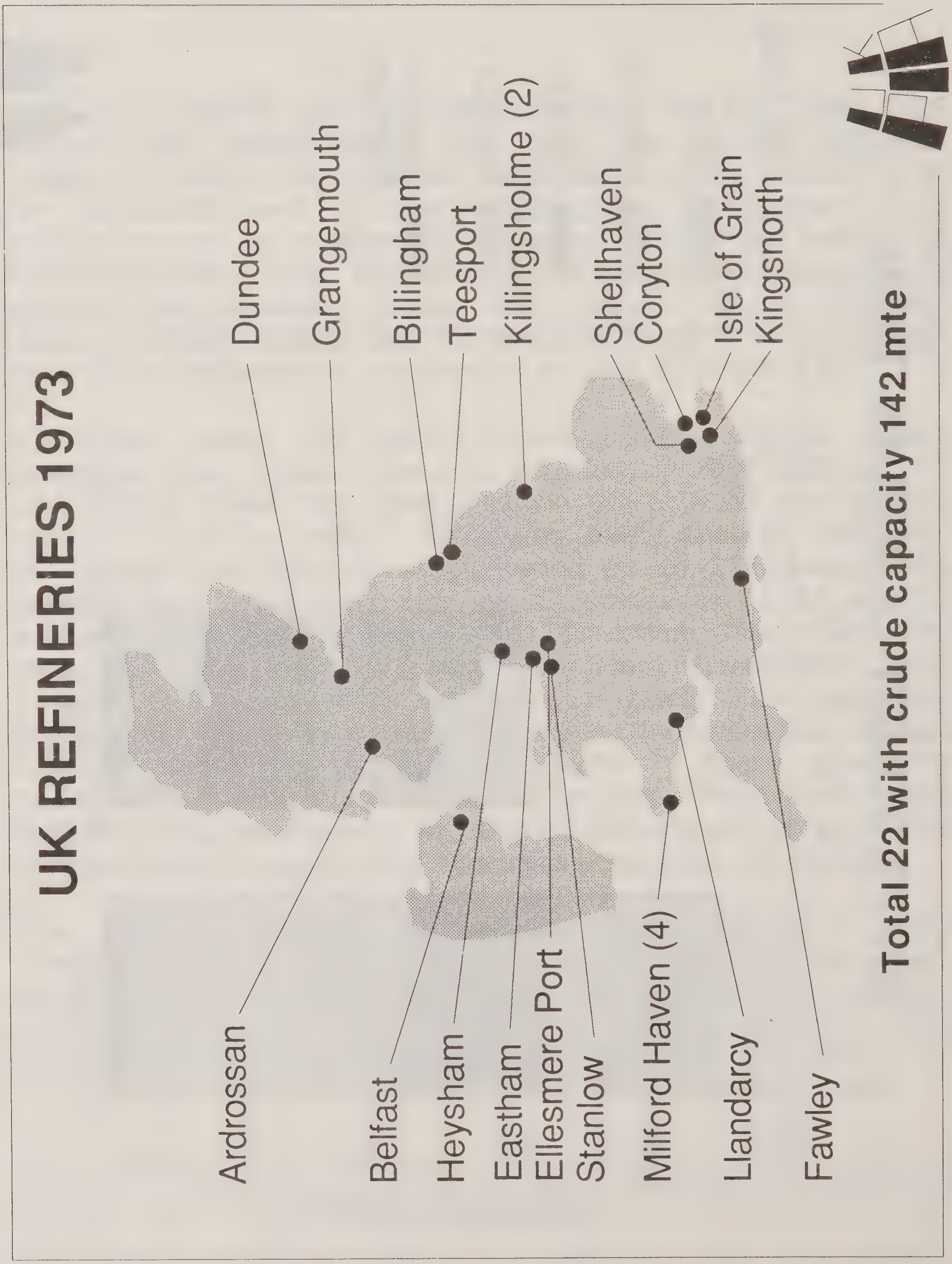

UK REFINERIES 1973
Dundee
Grangemouth
Billingham
Teesport
Killingsholme (2)
Shellhaven
Coryton
Isle of Grain
Kingsnorth
Ardrossan
Belfast
Heysham
Eastham
Ellesmere Port
Stanlow
Milford Haven (4)
Llandarcy
Fawley
Total 22 with crude capacity 142 mte

FIGURE 3

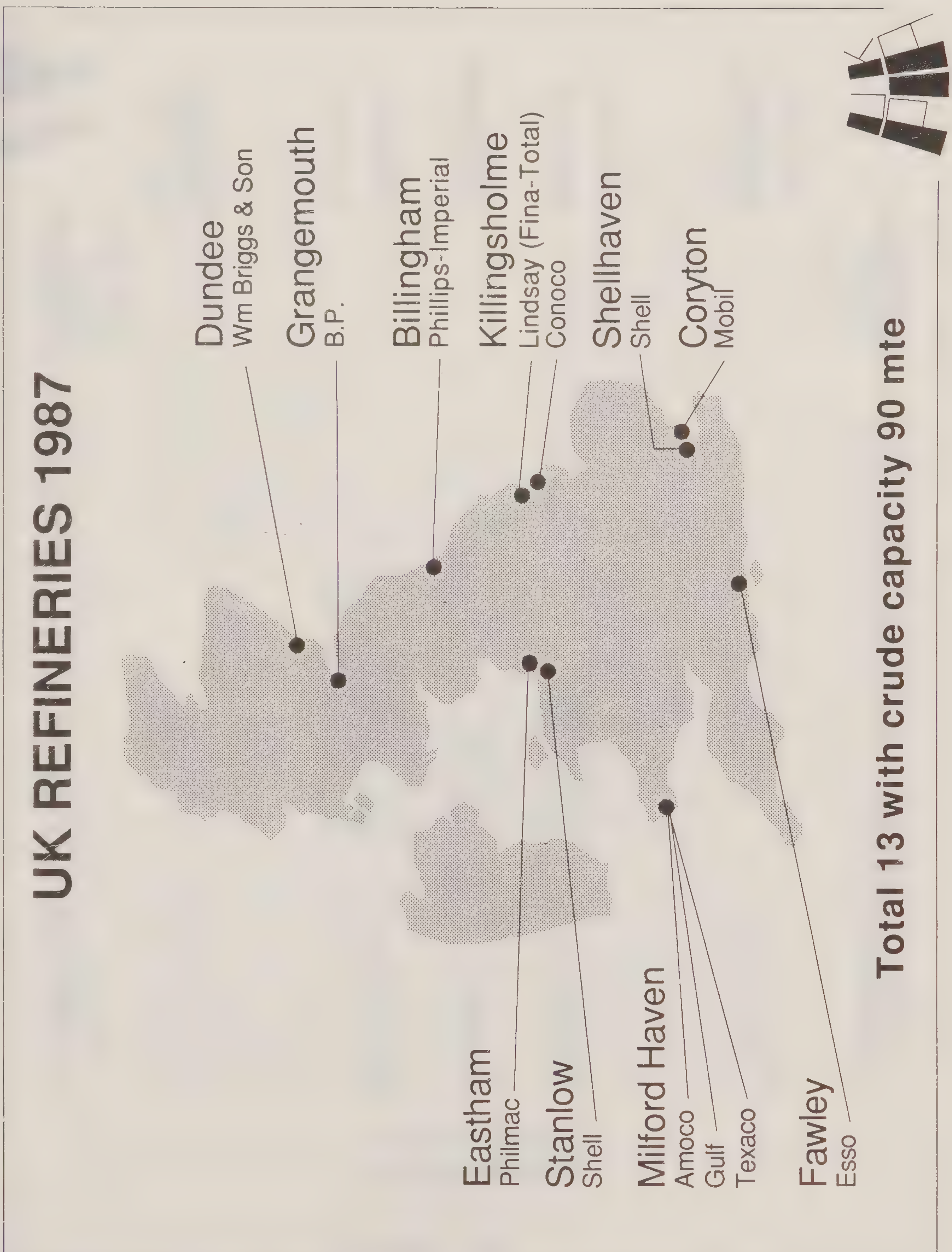

UK REFINERIES 1987
Dundee
Wm Briggs & Son
Grangemouth
B.P.
Billingham
Phillips-Imperial
Killingsholme
Lindsay (Fina-Total)
Conoco
Shellhaven
Shell
Coryton
Mobil
Eastham
Philmac
Stanlow
Shell
Milford Haven
Amoco
Gulf
Texaco
Fawley
Esso
Total 13 with crude capacity 90 mte

FIGURE 4

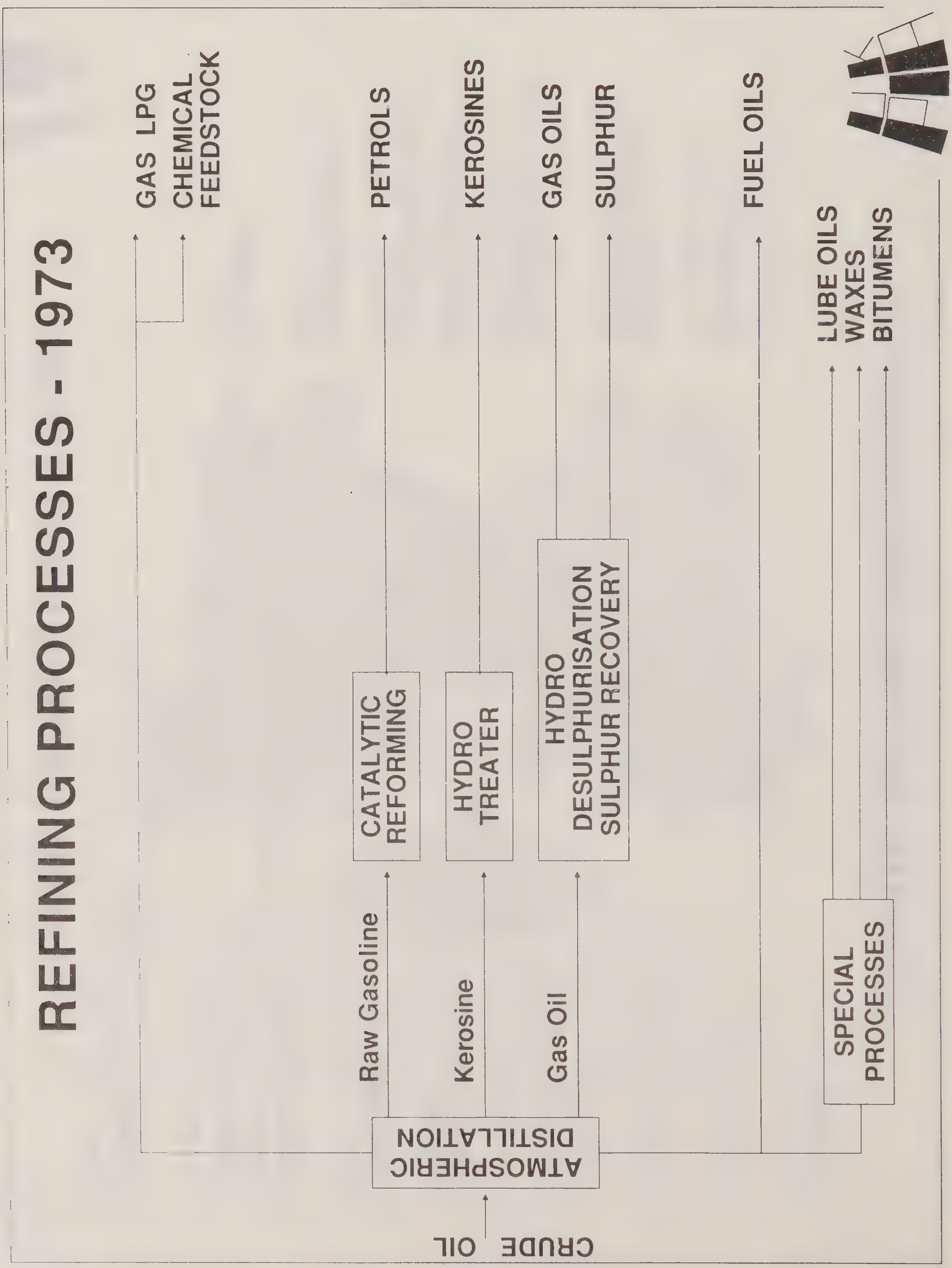

REFINING PROCESSES - 1973
CRUDE OIL
ATMOSPHERIC DISTILLATION
Raw Gasoline
Kerosine
Gas Oil
CATALYTIC REFORMING
HYDRO TREATER
HYDRO DESULPHURISATION SULPHUR RECOVERY
SPECIAL PROCESSES
GAS LPG
CHEMICAL FEEDSTOCK
PETROLS
KEROSINES
GAS OILS
SULPHUR
FUEL OILS
LUBE OILS
WAXES
BITUMENS

FIGURE 5

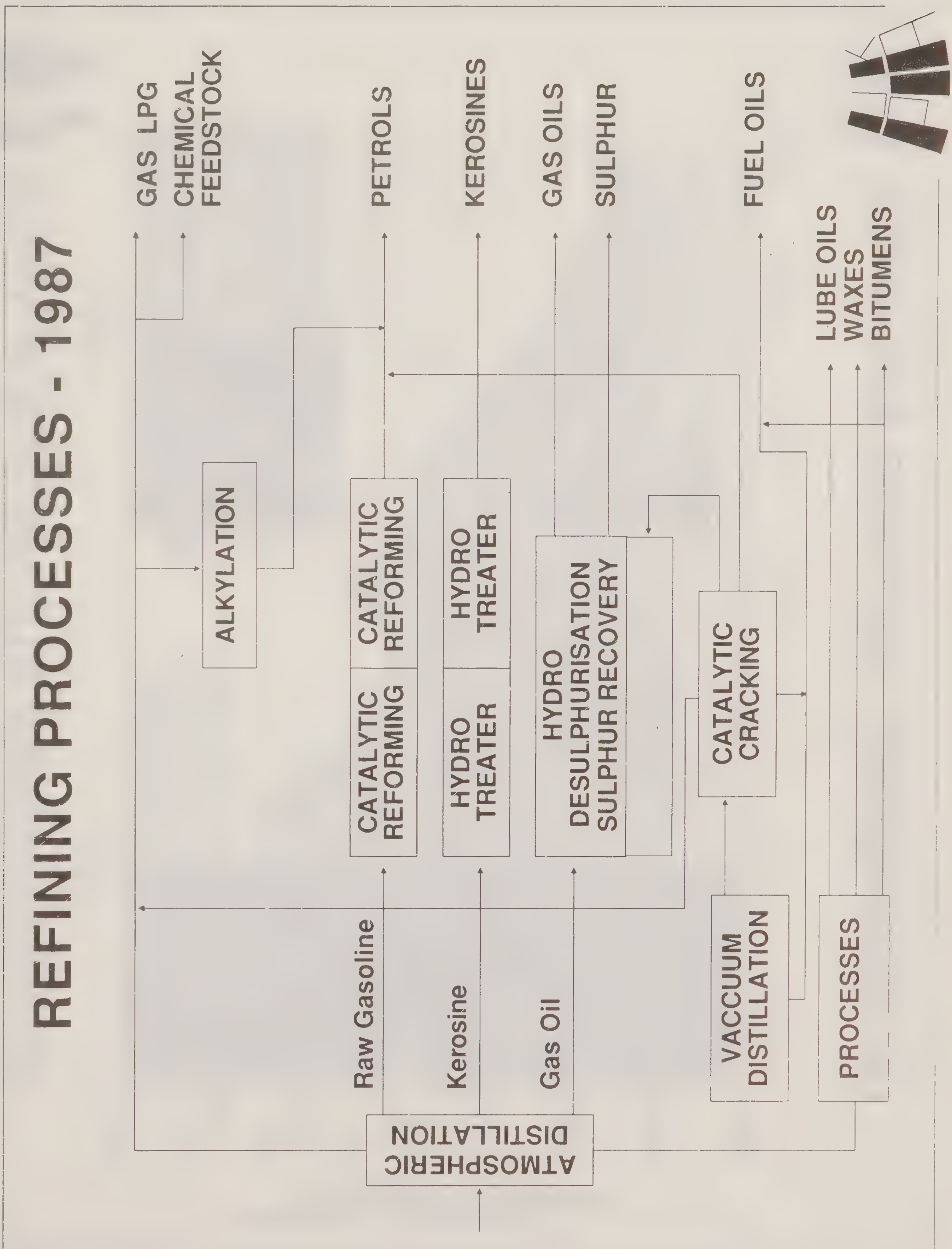

REFINING PROCESSES - 1987
GAS LPG
CHEMICAL FEEDSTOCK
PETROLS
KEROSINES
GAS OILS
SULPHUR
FUEL OILS
LUBE OILS
WAXES
BITUMENS
ALKYLATION
CATALYTIC REFORMING
CATALYTIC REFORMING
HYDRO TREATER
HYDRO TREATER
HYDRO DESULPHURISATION
SULPHUR RECOVERY
CATALYTIC CRACKING
Raw Gasoline
Kerosine
Gas Oil
VACCUUM DISTILLATION
PROCESSES
ATMOSPHERIC DISTILLATION

FIGURE 6

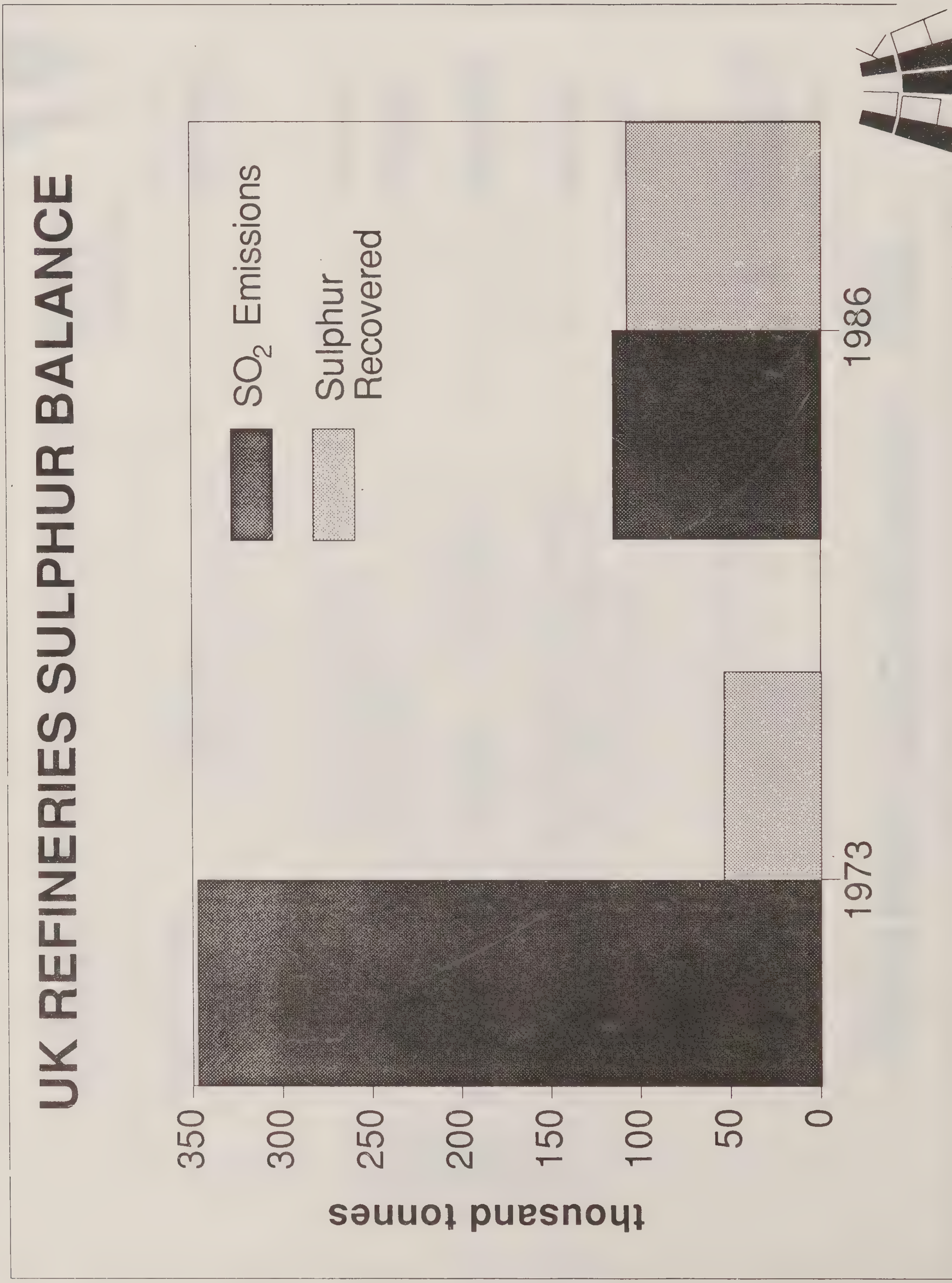

UK REFINERIES SULPHUR BALANCE
SO_2 Emissions
Sulphur Recovered
thousand tonnes
350
300
250
200
150
100
50
0
1973
1986

FIGURE 7

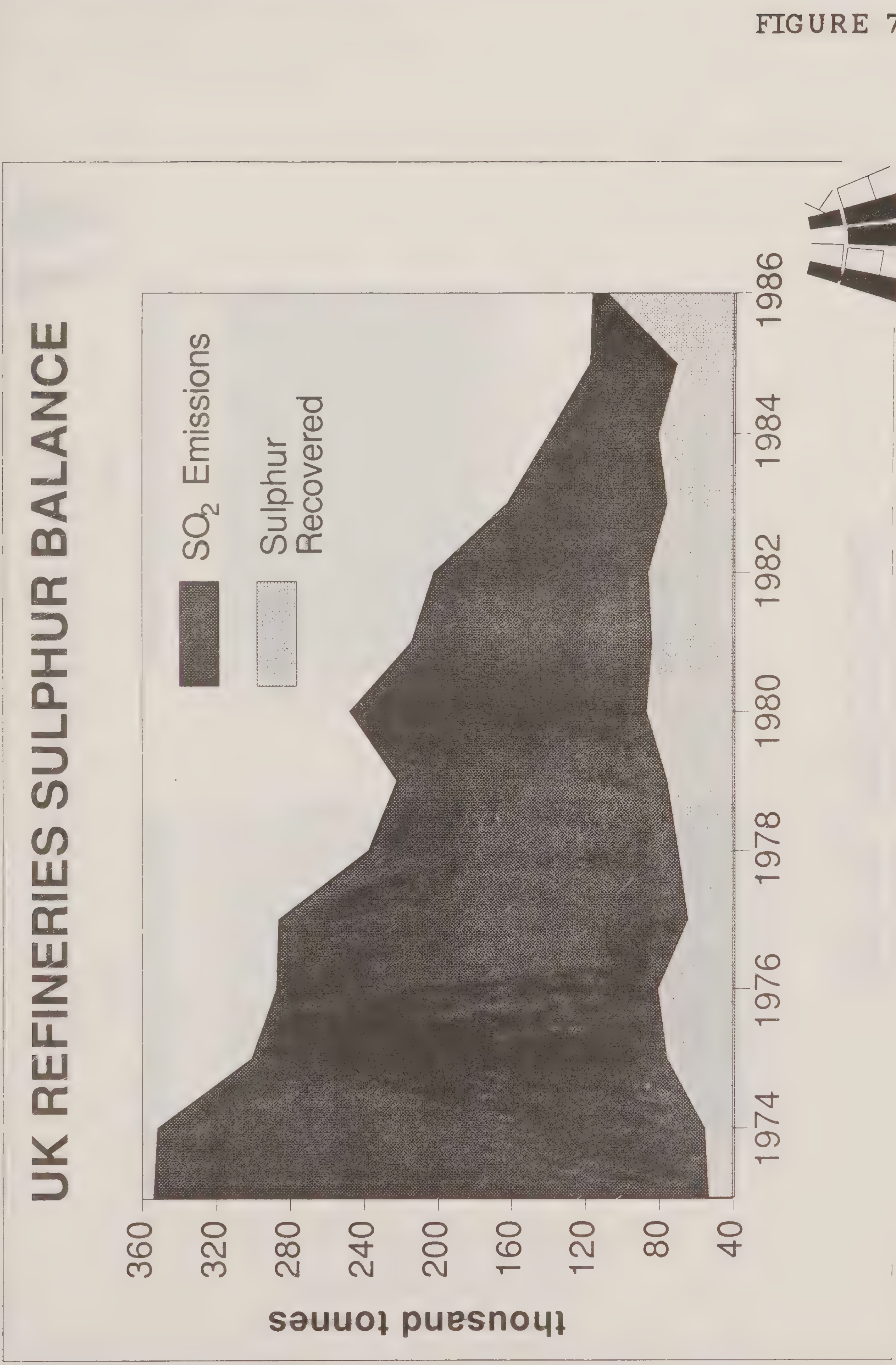

UK REFINERIES SULPHUR BALANCE
SO_2 Emissions
Sulphur Recovered
thousand tonnes
360
320
280
240
200
160
120
80
40
1974
1976
1978
1980
1982
1984
1986

FIGURE 8

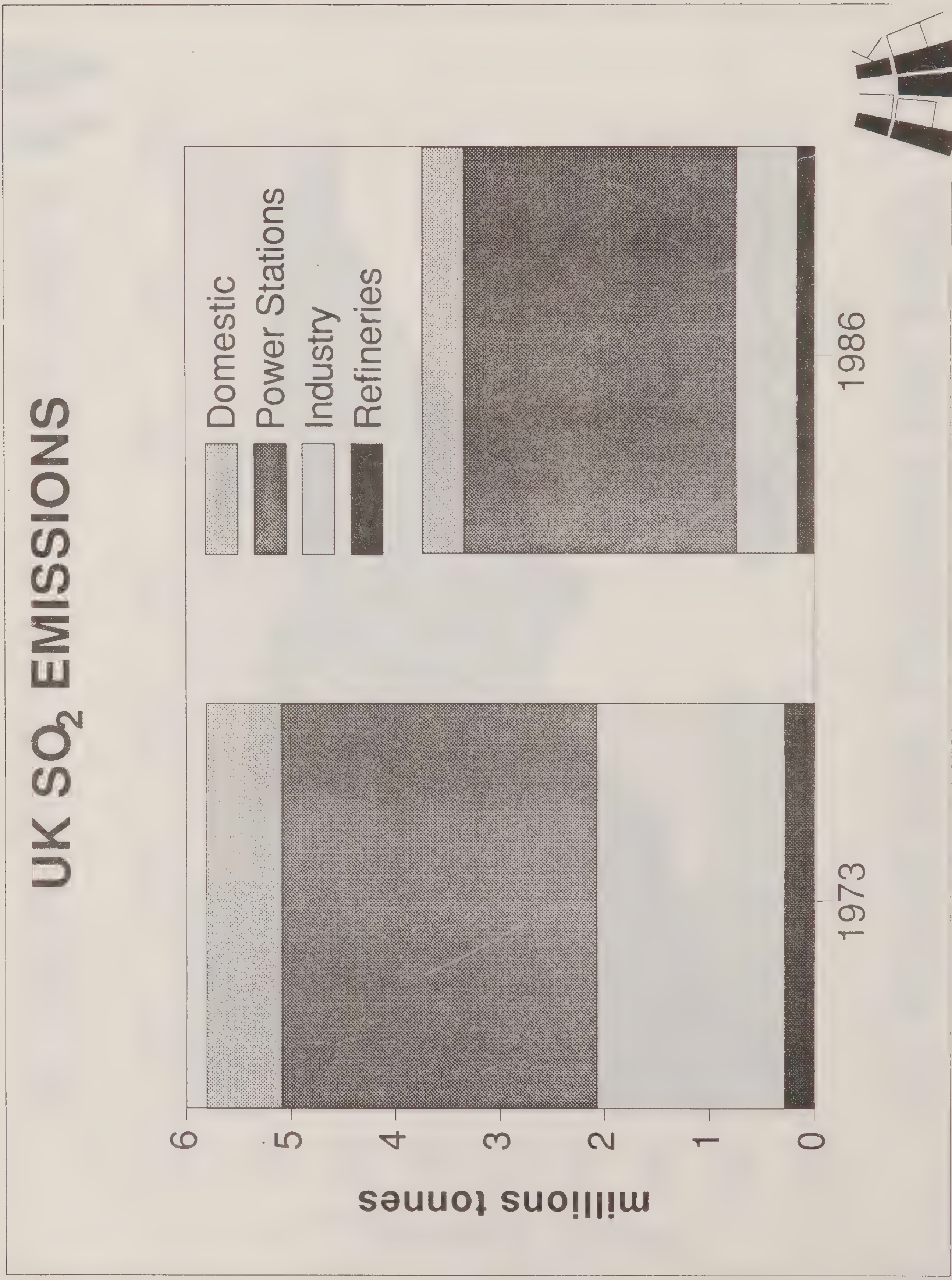

UK SO_2 EMISSIONS
Domestic
Power Stations
Industry
Refineries
millions tonnes
0
1
2
3
4
5
6
1973
1986

FIGURE 9

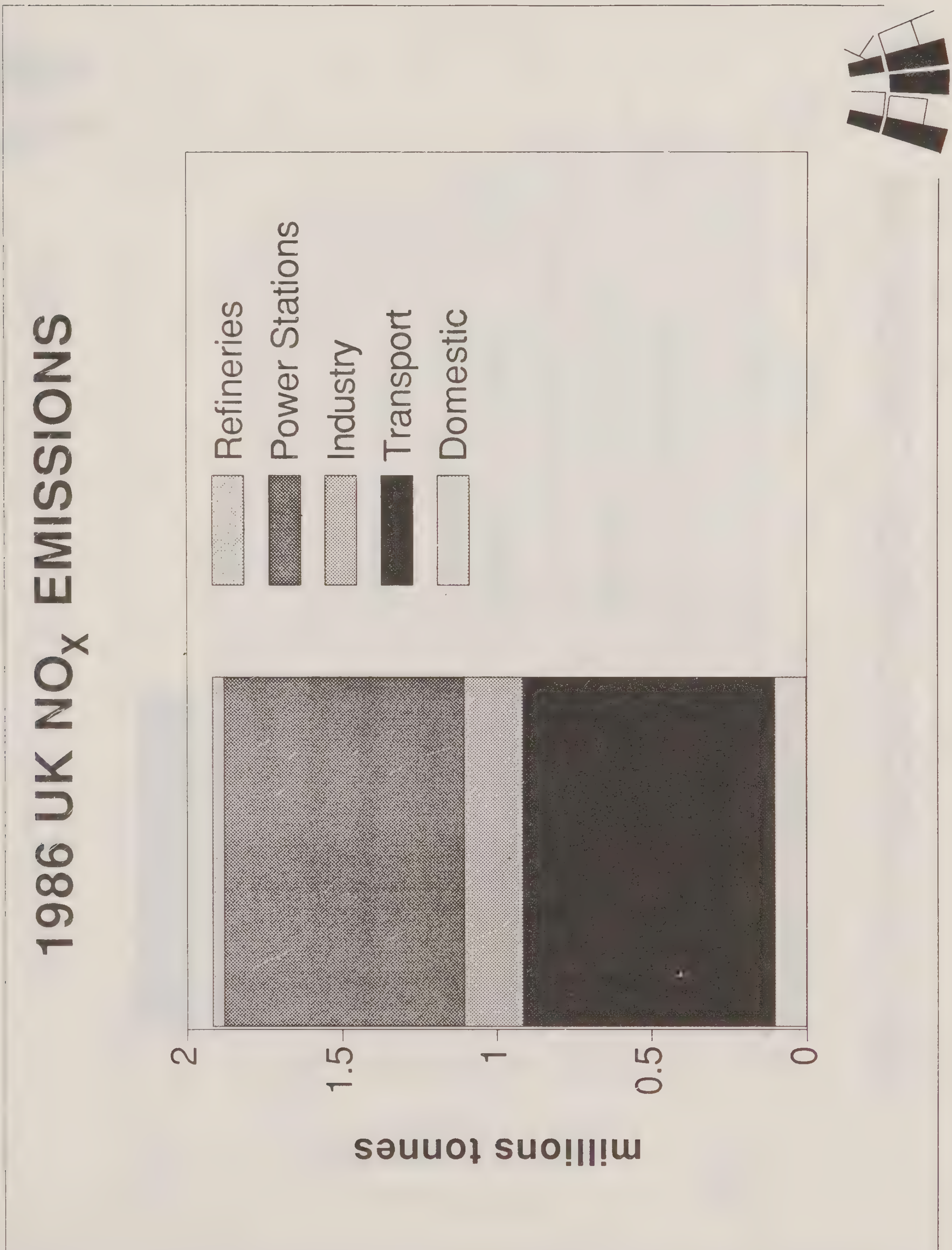

1986 UK NO_x EMISSIONS
Refineries
Power Stations
Industry
Transport
Domestic
2
1.5
1
0.5
0
millions tonnes

FIGURE 10

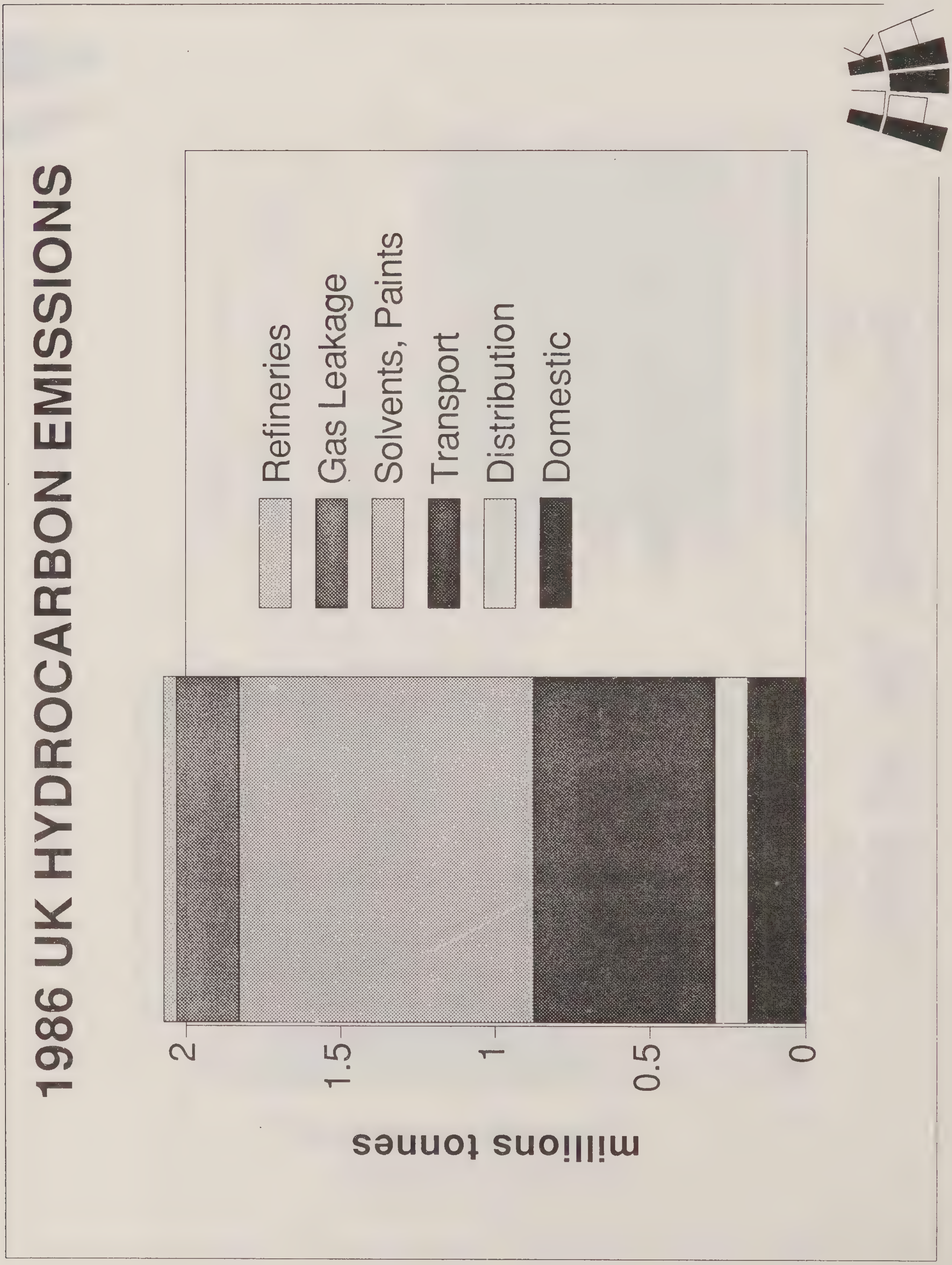

1986 UK HYDROCARBON EMISSIONS
Refineries
Gas Leakage
Solvents, Paints
Transport
Distribution
Domestic
2
1.5
1
0.5
0
millions tonnes

FIGURE 11

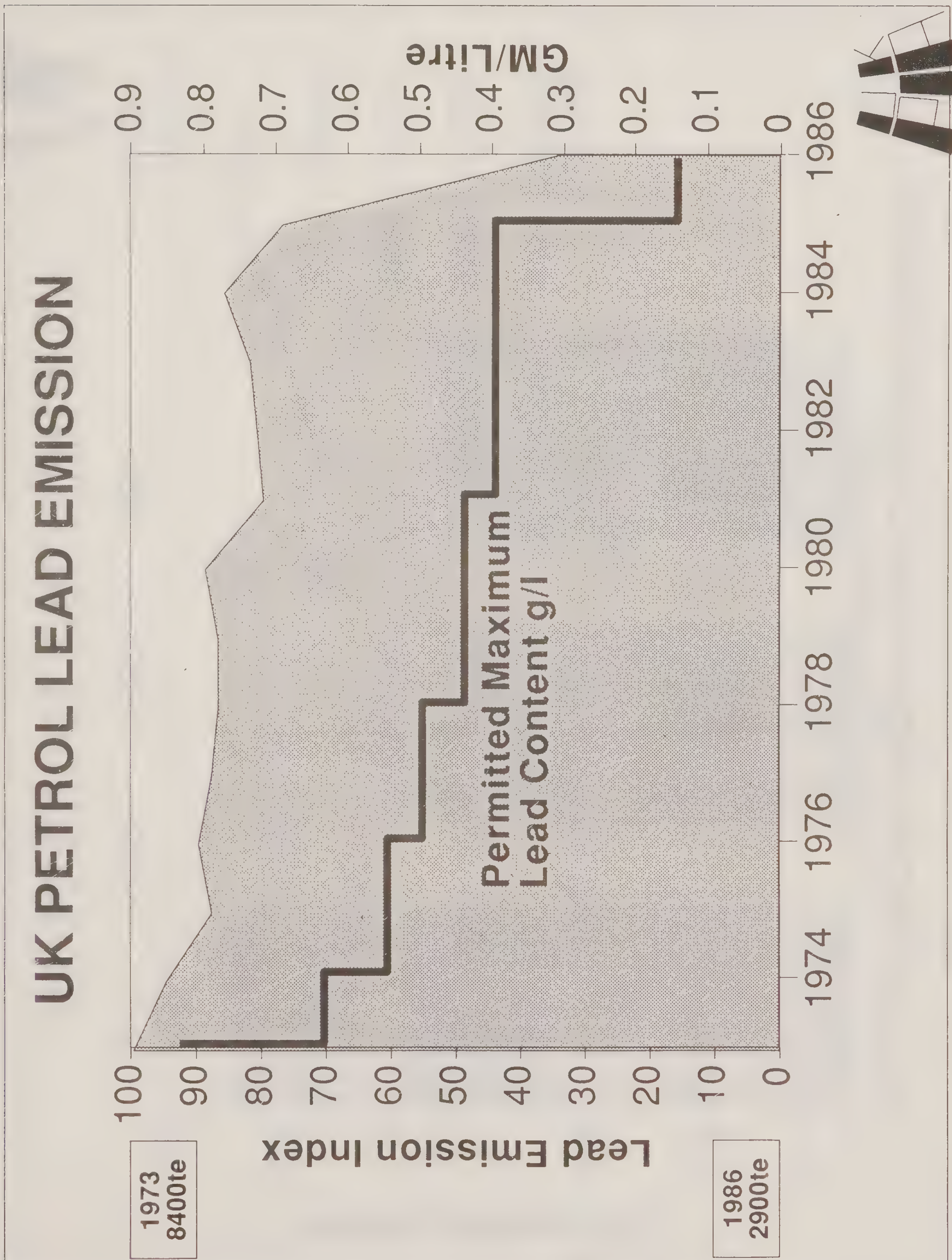

UK PETROL LEAD EMISSION
GM/Litre
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Lead Emission Index
100
90
80
70
60
50
40
30
20
10
0
1974
1976
1978
1980
1982
1984
1986
Permitted Maximum
Lead Content g/l
1973
8400te
1986
2900te

FIGURE 12

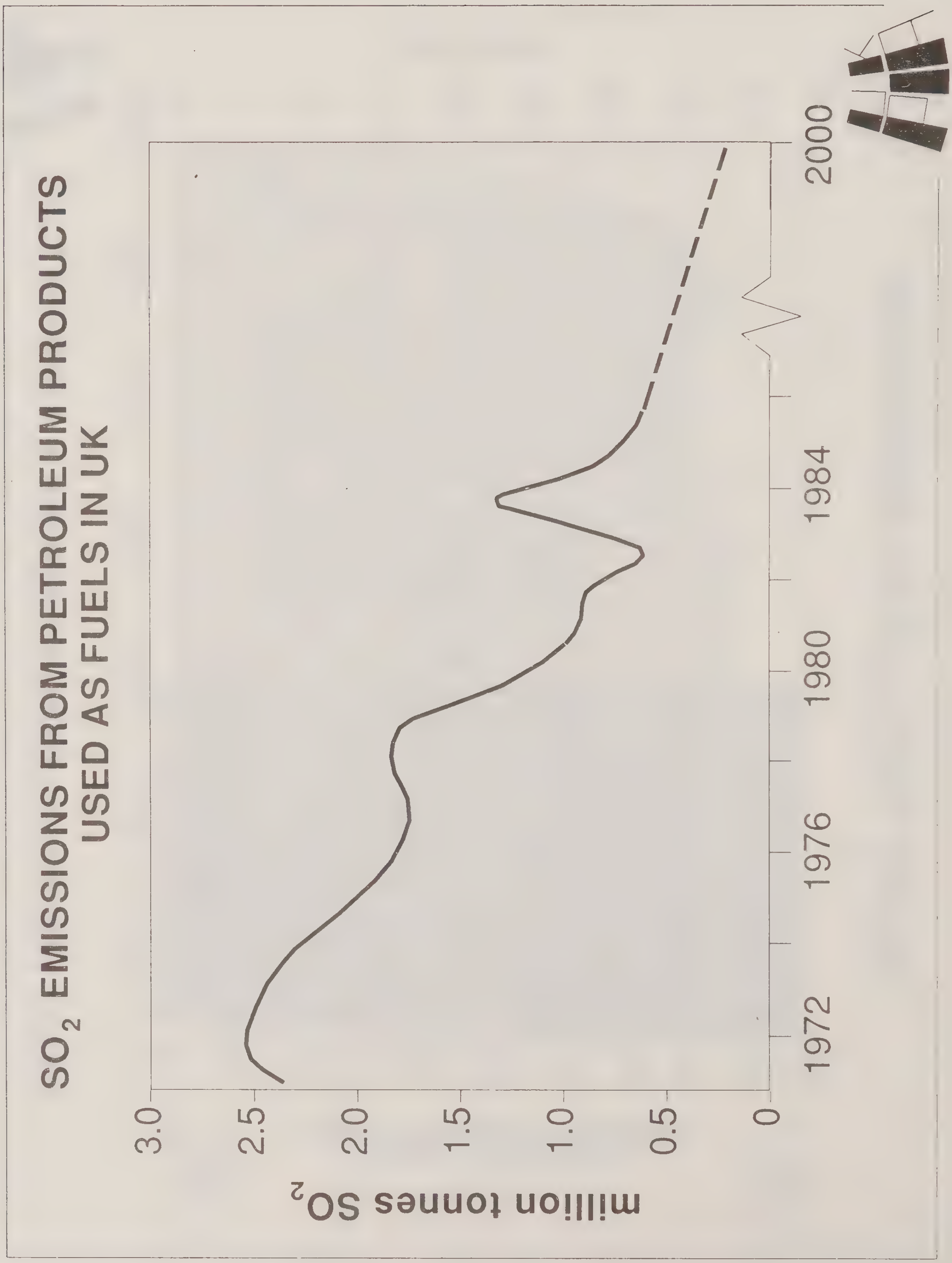
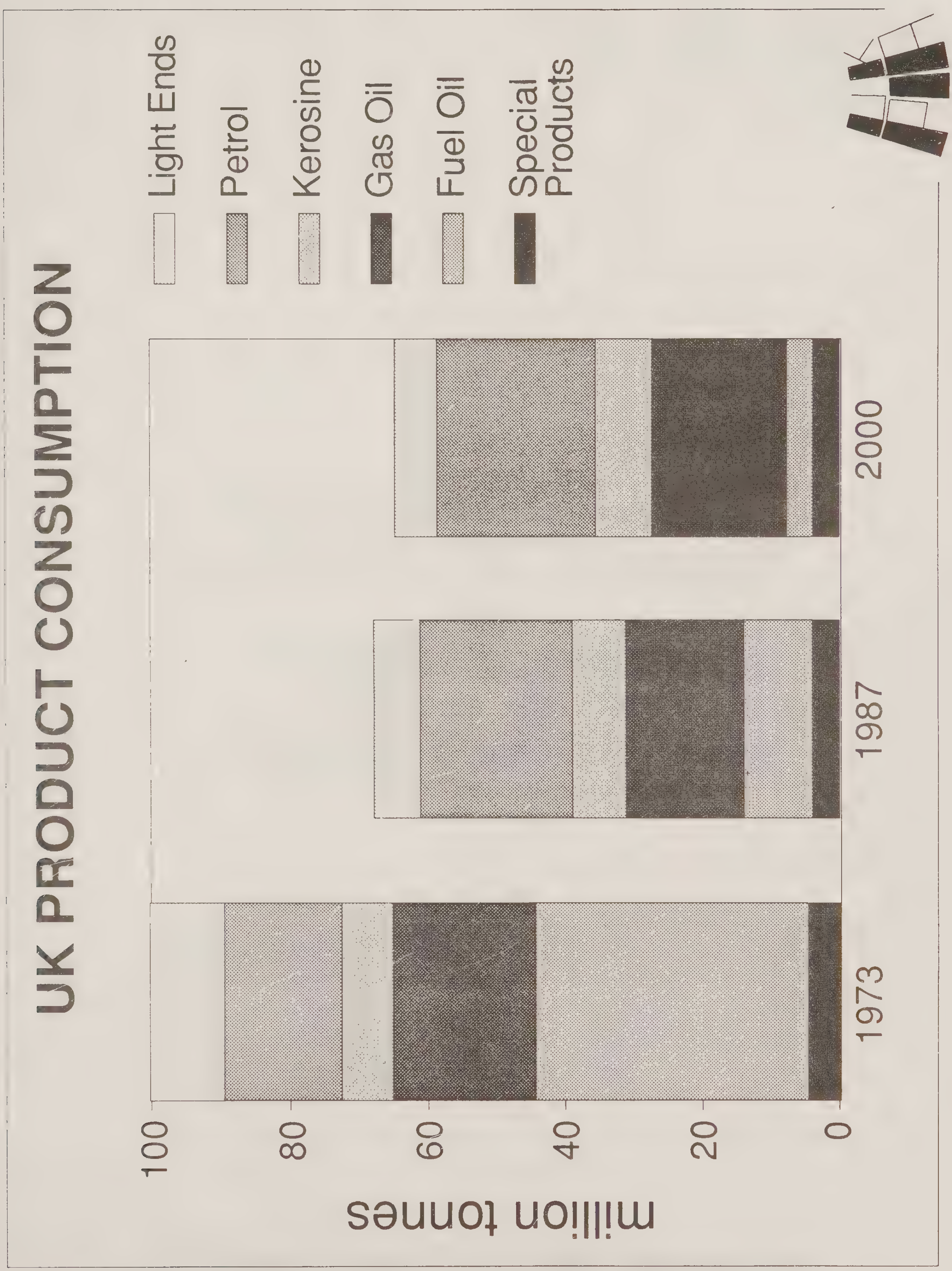

SO2 EMISSIONS FROM PETROLEUM PRODUCTS
USED AS FUELS IN UK
million tonnes SO2
3.0
2.5
2.0
1.5
1.0
0.5
0
1972
1976
1980
1984
2000

FIGURE 13


UK PRODUCT CONSUMPTION
Light Ends
Petrol
Kerosine
Gas Oil
Fuel Oil
Special Products
million tonnes
100
80
60
40
20
0
1973
1987
2000

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VEHICLES EMISSIONS CONTROL TECHNOLOGY

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Autocatalysts have been used since 1975 in the USA and Japan to control motor vehicle exhaust emissions of carbon monoxide, hydrocarbons and nitrogen oxides. Indeed, catalysts have been fitted to over 200 million motor cars around the world and Johnson Matthey has supplied over 100 million of them. In Western Europe increasing numbers of autocatalyst-equipped cars have been sold over the last few years and non-EEC countries have introduced US exhaust emission standards. In the EEC, following three years of negotiations, a directive was finally issued that will allow member states to introduce tougher exhaust emissions standards, starting in October 1988. Availability of unleaded petrol, necessary for autocatalysts to operate efficiently for the life of the vehicle, is increasing throughout Europe with complete availability in many countries. The fact that all the political parties in the UK are now committed to the protection of the environment should lead to further advances in controlling emissions.

My topic relates specifically to motor vehicle pollution control and, as we've already heard from Ian Berwick (UK Petroleum Industry Association), in the UK motor vehicles contribute just over 40% of nitrogen oxides. It should be noted that in other European countries they say that the contribution is higher than that - up to 70% - which relates to the relative importance of power station emissions and motor vehicle emissions; some countries rely very much more heavily on nuclear power than the UK. Motor vehicles also contribute something like 85% of carbon monoxide in the UK environment and 28% of hydrocarbons. Carbon monoxide, of course, is a poison, and where concentrations are high causes problems for people with weak hearts and bronchial complaints. Hydrocarbons and carbon monoxide also contribute to photochemical smog through the formation of ozone; both are contributors to acid rain.

The catalyst technology adopted by the motor industry is based on the platinum group metals of platinum, palladium and rhodium, supported on a ceramic or steel honeycomb. Two forms of autocatalyst are in common use. The 3-way autocatalyst, when used with electronic fuel injection and an

exhaust sensor, controls all three emissions of carbon monoxide, hydrocarbons and nitrogen oxides. An oxidation catalyst removes carbon monoxide and hydrocarbons and can be used to make lean burn engines cleaner, without spoiling their fuel economy advantages over conventional engines.

Going back in history, a disastrous fire in a coalmine in 1812 prompted the scientist Humphrey Davy to work on ways of protecting miners and his researches led to the safety lamp. He discovered that platinum wire could cause the combustion of coal gas, and that principle, the catalytic combustion of a mixture of hydrocarbons, carbon monoxide and hydrogen, is in fact the principle which has been used for flameless combustion for a number of applications; some, like catalytic heaters, are in domestic use, others like catalytic incinerators are used in industry to control hydrocarbon and nitrogen oxide emissions and of course for the control of pollutants from motor vehicles. However, the landmark in the development of catalyst technology was the development by Johnson Matthey of platinum/rhodium catalysts for the control and reduction of nitrogen oxides from nitric acid plants. That principle - the use of platinum/rhodium to reduce nitrogen oxides - is now the most commonly used system to control vehicle emissions, the three-way catalyst.

There are various types and forms of catalyst which can control hydrocarbons, nitrogen oxides and carbon monoxide, provided they are used with unleaded petrol. As we heard earlier that is now becoming more widely available but not widely used enough. One point I'd like to make here is that in those markets where the use of catalyst systems to control the emissions from motor cars has been encouraged either through legislation or by government incentives - for example taxation incentives to people who purchase clean cars - sales of unleaded petrol have taken off much faster than just that required for the vehicles with catalysts that have to use unleaded petrol all the time. So catalysts are in a sense catalysing the use of unleaded petrol in other markets and we have proposed to the UK government that one of the ways of making people more aware of the use of unleaded petrol is to promote the cleaning of other emissions from motor cars. National publicity campaigns will help in

this. In addition more manufacturers are launching catalyst-equipped cars.

What is the role of Government in all of this? It is partly to introduce appropriate legislation, and I shall outline later how far the UK has got with legislation to control emissions from motor vehicles; it could also be to encourage people to drive clean cars through some sort of differential taxation. Unfortunately, I fear that few people will actually choose to pay even the little extra that is being asked for clean cars on a voluntary basis. When people get into the car showroom they will find other features more attractive; for the majority of people such things as electronic stereo systems, six speaker radios and power steering are more attractive than controlling the pollution from the back end of your car, because unfortunately it's not your pollution, it's the guy in front that you're concerned about.

As I mentioned earlier, catalysts are based on the platinum group metals, supported on a ceramic or steel honeycomb; this is merely a collection of holes through which the exhaust gases pass and in doing so they encounter the catalyst coated onto the walls of the honeycomb. The surface of the catalyst is very rough, and into each cylinder we can cram an area equivalent to three football pitches. The reason for that is, we then coat around one and a half grammes of precious metal - that is platinum, rhodium and/or palladium - onto the surface and because the precious metals are relatively expensive we need to spread then out very very thinly over those three football pitches to protect them for the life of the vehicle. Having done that, the catalyst will operate - provided unleaded petrol is used, provided the vehicle is used and maintained properly - for the life of the vehicle. One and a half grammes of precious metal, incidentally, would cost about £20 at current prices, so it is expensive but not horrendously expensive in today's terms.

Without going into too much detail about how a vehicle works, it is useful to explain what goes in and what comes out of a motor vehicle in terms of pollution. The four-stroke petrol engine can be summed up 'suck, squeeze, bang, blow' - those are the four cycles - we suck in a

mixture of air and fuel (petrol, in the case of the petrol engine), squeeze it, ignite it so that it burns, and then blow the exhaust gases out of the back end. Unfortunately, as you will know, that process can be happening 7,000 times a minute. There isn't a lot of time for completionof the combustion process - there are crevices in the engine where the flame does not reach and so, coming out of the back end of the vehicle we have a number of things: we have carbon monoxide, which is a product of partial combustion of petrol; we have carbon dioxide, which is the complete product of combustion; we have hydrocarbons - petrol that hasn't burned or has only partially burned, and we have nitrogen oxides which are an inevitable product of high-temperature combustion. They are formed at the flame front by reaction between nitrogen and oxygen from the air and the levels that come out are frozen at the level that relates to the peak temperatures achieved within the engine. We have a small amount of sulphur dioxide as a result of the sulphur that's left in the fuel and of course we have lead added to the fuel and that comes out as lead compounds - lead oxides, lead sulphates, lead bromides and chlorides. And then finally, we have some air left, certainly depleted in oxygen but most of the nitrogen is there, and we have water as the final product of combustion.

Another means of reducing pollution from vehicles is the lean burn engine which operates with an excess of air. Emissions of carbon monoxide and nitrogen oxides fall, but power also falls. If you put less petrol into the engine, you get less power out - you don't get anything for nothing.

What can we do about these polluting emissions? Well, the simplest form of catalytic treatment is the oxidation catalyst, sometimes known as the two-way catalyst; this is very simply a catalyst that completes the combustion of fuel after it has left the engine, that wasn't combusted within the engine because of lack of time. The exhaust gases pass out through the catalyst; if it is necessary to add extra air to provide the oxygen needed to burn the petrol then an air pump or valve can do that, but in the case of lean-tuned engines there is enough air there anyway, and then merely fitting the catalyst into the exhaust system will complete that combustion process and get rid of the hydrocarbons and

carbon monoxide. It needs, of course, unleaded petrol.

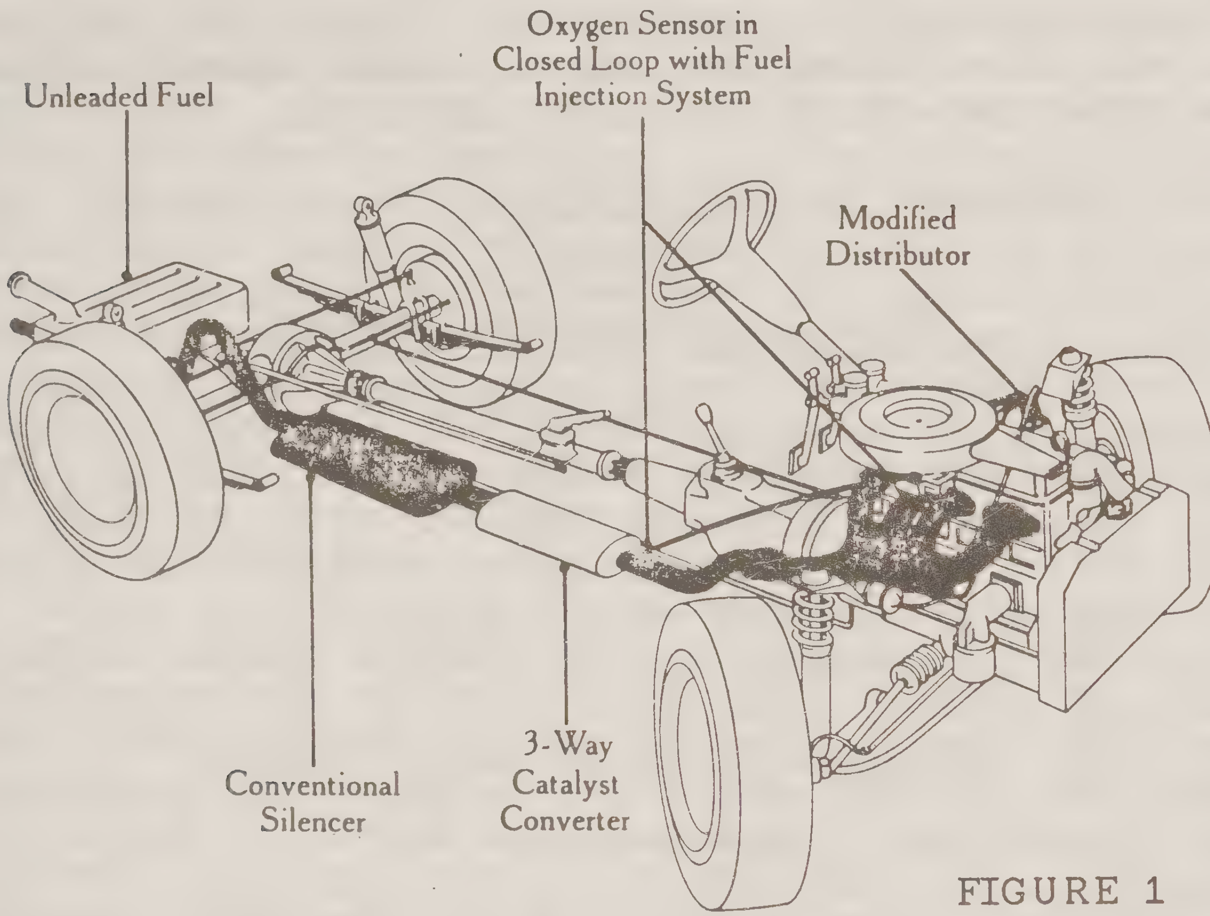


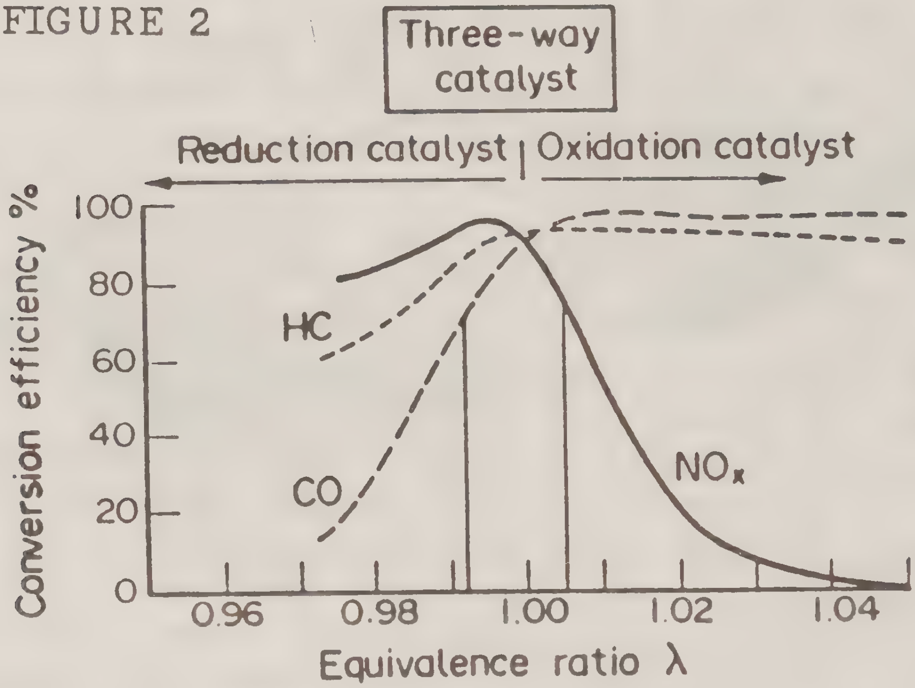
FIGURE 1

The more sophisticated system which is fitted to the majority of cars being sold in the States, Japan, Australia and increasingly in Europe, is the three-way catalyst. This controls, as the name suggests, the three pollutants - carbon monoxide, hydrocarbons and nitrogen oxides; it works by balancing the air and fuel in a ratio such that the nitrogen oxides which are a very powerful oxidising agent can be used to turn the carbon monoxide and hydrocarbons into carbon dioxide and water. In doing so, the nitrogen oxides are stripped of their oxygen and become nitrogen; so it's very neat - you neutralise your pollutants and the products of combustion are carbon dioxide and water and nitrogen - all of which are present in the atmosphere, and with the exception of carbon dioxide and the possible concern about the "Greenhouse Effect" can be said to be harmless. But of course, if one wants to reduce carbon dioxide levels, then one needs to use less fuel, less fossil fuel, in transport applications, because ultimately all the carbon coming out of the engine as carbon dioxide or carbon monoxide or

hydrocarbons and the nitrogen oxides, end up as gases which contribute to the Greenhouse Effect.

So, how do we effect the balance in the engine? Figure Two shows the sort of thing we're looking for. This is what

FIGURE 2



The conversion of all three pollutants over the three-way catalyst can be maximized under stoichiometric fuelling conditions (air:fuel ratio of 14.7:1 or $\lambda = 1$).

FIGURE 3

comes out of the catalyst, the axis on the left-hand side shows percentage removal of pollutants, going up to 100% at the top, and equivalence ratio or air/fuel ratio along the bottom axis, showing what happens as you move from the rich side through to the lean side, and in the middle, the zone at which all three pollutants are controlled to 90% or more. To get that balance, we use a device known as an oxygen sensor or a lambda sensor in the exhaust that actually measures, coming out of the engine, the ratio of oxidising to reducing components. These have been around for more than ten years, they are a device that looks like, but costs a little bit more than, a sparkplug, and bolted into the exhaust system they give a feedback into the electronics

that control the fuelling. This is normally fuel injection or a clever carburettor and that adjusts the ratio of air to fuel going into the engine. The advantage is that the engine is being continuously tuned.

Moving onto European legislation, I can only, in the time I've got, highlight one or two things. Firstly, the journey that we are now reaching the end of in terms of European emissions legislation, started really in 1976 when the German government published a document calling for further controls on exhaust emissions. Then there was a significant UK initiative when our government committed us to unleaded petrol in April 1983 just before the election before last; this was followed up by the Federal Republic of Germany, who decided to move ahead on its own and not wait for the rest of Europe when it announced its intentions to legislate for emissions control catalysts in January 1986. In the event, they weren't allowed to do that, under pressure from the rest of the Common Market, and an agreement called the Luxembourg Agreement was set in June 1985. It was vetoed by Denmark and Greece initially and for a long time, it was just that: an agreement in principle but nothing actually happened. That veto was finally lifted through the European Single Act, 1986, which in certain circumstances allows majority rather than complete agreement. Finally in February 1988 the Commission introduced a Directive which allows Member States to set emissions standards in their territories but does not make it compulsory so that there is

EEC REGULATIONS ON CAR EXHAUST EMISSIONS

ENGINE SIZE	INTRODUCTION DATES NEW MODELS	ALL NEW CARS	EMISSIONS (g/test) CO	HC+NOx	NOx
Over 2 litres	1.10.88	1.10.89	25	6.5	3.5
1.4 - 2 litres	1.10.91	1.10.93	30	8	-
Under 1.4 litres					
Stage 1	1.10.90	1.10.91	45	15	6
Stage 2*	1.10.92	1.10.93	30	8	-

* Proposal from the European Commission

an outline framework with dates and standards, but it left to Member States to decide on implementation. The dates of implementation are fairly complicated; the cars are divided into three categories, large cars over 2 litres, medium cars from 1.4 litres, and small cars under 1.4 litres. The significant factors are that the large car standards could be implemented as early as October 1988 for new models of cars, coming into the market for the first time from the 1st October, and 1st October 1989 for all cars sold. The standard is, however, about twice as lax as the American standards; it does not represent the full use of state of the art technology. It was formulated to give the same impact in environmental terms as US standards, taking into account different patterns of transport use, but in absolute terms it is about double the US standard.

One important point is the Stage 2 standard for small cars - the Stage 1 is only a small change from current technology - the Stage 2 standard is still only a proposal. It was agreed by a majority in June 1988; France subsequently withdrew their agreement and so there is not now a majority on that agreement, and this was to be discussed at the Environment Minister's meeting in November. Another important point is that member states are moving now at different speeds towards implementation - Germany and Holland, who have been 'hawks' in this, will implement on the earliest possible date; even France is implementing with only one small change and that is they are not using the 1st October 1988 date but will bring it in for large cars from 1st October 1989. The UK is delaying the large car standards until 1991/1992 so we will have to wait another three years before our large cars start to use technology which they have been selling in export markets for the last twelve or thirteen years.

What do these standards mean? Well, in the case of 2 litre cars and over, the use of fairly conventional engine technology with three-way catalysts - the standard technology used in the United States - and there is not too much argument about that; in medium cars, some vehicles will undoubtedly use those systems, others will use lean burn engines fitted with oxidation catalysts in order to control the hydrocarbon emissions, and the same is expected to apply to

the stage 2 standards of the small cars when those are implemented.

To summarise very briefly some of the strategic issues for Europe:

1. High speed operation: concern has been expressed on the operation of 3-way catalysts at high speeds of cars. In order to put that one to rest, we and motor manufacturers have run cars for up 50,000 miles at maxiumum speed and at the end of those tests the cars still meet the California emissions standards to which they were designed, those standards being the tightest anywhere in the world, even though exhaust temperatures are in excess of 1,000°C and speeds up to 170 km per hour have been reached.

2. Small cars - is there space on small cars? We tested a fleet of Peugeots, Fiats, Volkswagens and Rovers, all under 1.4 litres. The catalyst fits very neatly on most of those cars in front of the engine into a place that could have been made for it; fitting a catalyst and doing nothing more to the engine brings the emission limit down below those that have been proposed by the European Commission for Stage 2, and almost down to the level which the European Parliament have suggested, equivalent to US standards.

Can we meet European emissions standards without catalysts? Well, various engines have been claimed to do just that and some manufacturers, Peugeot and Volvo, have been selling non-catalyst cars in Germany meeting the proposed standards. The problem is that the current European standard only uses a very low speed test cycle, average speed 12 miles per hour, maximum speed 30 miles per hour. The engine is only using a little of its power to drive that cycle. When you take it out at higher speeds, up to 120 km per hour, you see that the non-catalyst version of a Peugeot and a Volvo exceeds the catalyst version by a factor of 23 on hydrocarbons, 400 times as much nitrogen oxides. So how is this being addressed? Well, all emission tests are based on a standard test cycle driven on a rolling road. As I said earlier, if you drive lean, then emissions are low but power is low. What happens on a lean burn vehicle if you go rich is that power increases but so too do the emissions of

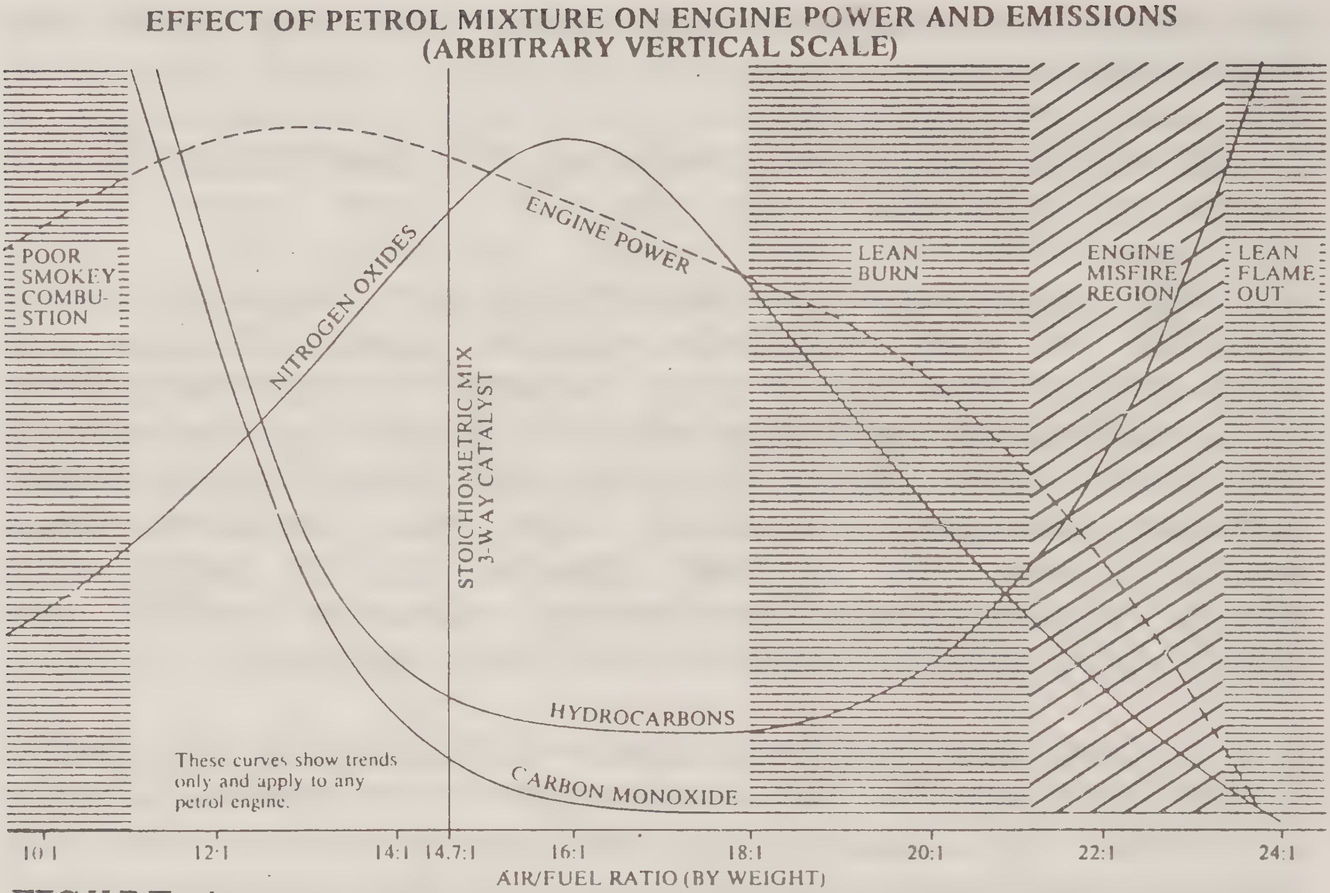


FIGURE 4

nitrogen oxides; this has now been recognised and an additional sector is currently being added on to the European driving cycle, which now goes up to speeds of 120 km per hour, albeit only for short periods; this is a considerable increase in the speed of that sector and is going to make it difficult for non-catalyst technology to meet the requirements. What, therefore, are the advantages of

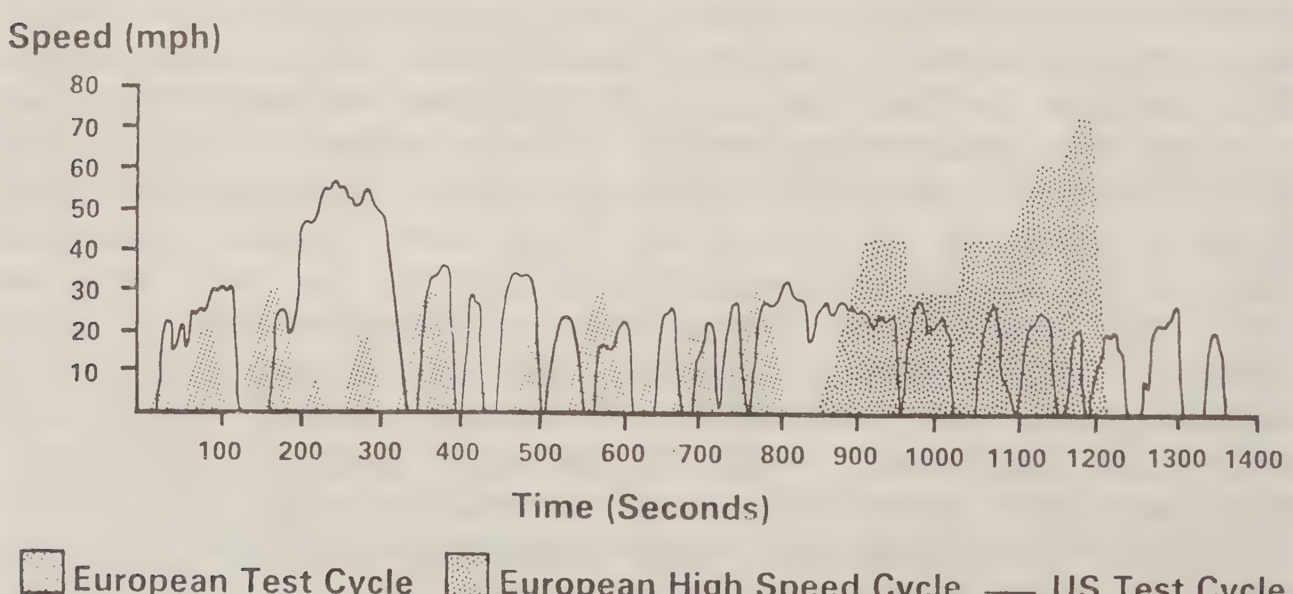
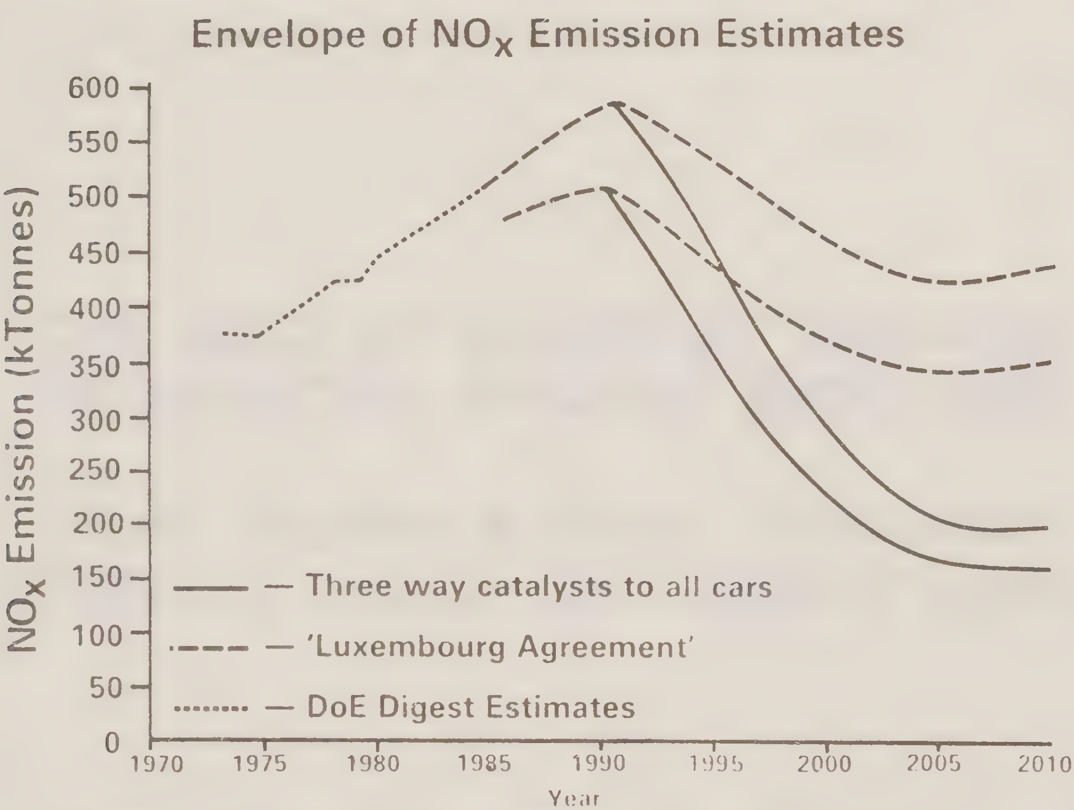


FIGURE 5

lean-burn? Fuel economy and reduction of nitrogen oxides at low speeds; however vehicles do need catalysts to become truly clean, because lean burn engines do not reduce hydrocarbon emissions significantly, nor do they eliminate pollution at higher speeds.

Autocatalysts, however, work at all speeds, do not affect fuel economy and can remove all three pollutants, but not lead. Figures produced by Warren Spring laboratory show that if we go to three-way catalysts and US technology, this will mean about half the nitrogen oxide levels in the early



Source: DTI Warren Spring Laboratory Report LR612 (AP) M

FIGURE 6

years of the next century. And for once, Britain does have the the technology; this is not a case of tightening emission standards and then having to import the technology from Germany, the USA or Japan - Johnson Matthey is in fact the world leader, supplying about 40% of the autocatalysts used worldwide by motor manufacturers. So far as price is concerned, Government estimates made earlier in 1988 suggest £100 for small cars, £150 for medium cars and £370 for large cars meeting the full US standards; the effect on fuel economy is minimal, on performance it is about 2 mph off the top speed and 0.51 seconds of the 0-60 mph time.

Finally, to sum up: if autocatalyst technology is to become more widely accepted, we need more Government support in terms of regulations and in terms of some kind of incentive to the motorist; and we need more public support - unless the public demand clean cars they are unlikely to become more readily available.

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THE ROLE OF ELECTRIC VEHICLES IN REDUCING TRAFFIC EMISSIONS

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There is increasing awareness of the damage caused by emissions from road vehicles, particularly in industrialised countries, where transport is responsible for about half the air pollution from human activities. Pollution from traffic is a particular problem as it is concentrated in the areas where people live and is at its worst in congested city centres. Table 1 shows the typical exhaust gas composition from a car during the ECE driving cycle, which represents normal driving conditions in towns[1].

Carbon monoxide, hydrocarbons, nitrogen and sulphur oxides are recognised as potential pollutants, and with the exception of nitrogen oxides, would generally be reduced in higher speed driving outside city centres. The hydrocarbons comprise a wide variety of substances, some of which, such as benzol, are known to be highly carcinogenic. Diesel engines generally emit less carbon monoxide and nitrogen oxides but more sulphur oxides and aldehydes, together with considerable quantities of particulates.

An indication of the vast quantities of the main air pollutants from traffic, within the context of total man made emissions in industrialised countries, is given in Table 2.

It will be noted that in the UK transport emissions of nitrogen oxides are a small proportion of the total, but the UK Department of Energy considered that nitrogen oxides from traffic could be 15% greater than those given.[3]

EFFECTS OF TRAFFIC EMISSIONS

Hydrocarbons and nitrogen oxides from road transport are a major constituent of ozone, which is damaging to human health, plants and trees. Nitrogen oxides form approximately a third of the acidity in rainfall, exacerbate the formation of sulphure into acids, and they are second only to sulphur oxides in causing damage to stonework. Traffic emissions are the major source of carbon monoxide, which may impair human health, and also contain a significant proportion of particulates which are known to have carcinogenic and

mutagenic effects, particularly for people in their immediate vicinity. High levels of carbon dioxide, while not in themselves harmful, may in the long term contribute to the 'greenhouse effect', which could cause climatic changes, flooding and drought in different parts of the world.

ELECTRIC VEHICLES TO REDUCE POLLUTION

There are three main ways in which the electric vehicle industry is seeking to drastically reduce emissions from road traffic. The first is to utilise present electric vehicle technology, in conjunction with stringent controls on emissions from power stations. The second is to build hybrid vehicles, which could be powered by electricity in environmentally sensitive areas, while for longer distances, the engine can be utilised more efficiently. The longer term solution is to develop fuel cells, powered by either methanol or hydrogen, which would be extremely clean. Fuel cells could also be used for generating electricity from power stations for future battery electric vehicles.

Comparative emissions ICEVs/EVs

A general comparison of the pollution from present internal combustion engined (ICE) vehicles with that of electric vehicles (EVs) can be made by assessing the emissions per kilometre travelled for a passenger car. Given the emissions data in Table 2 and the fact that approximately 200 billion kilometres are travelled annually by cars in the UK, plus 40 billion kms for larger vehicles, which cause about double the pollution of cars, this would mean that the emissions would be approximately as shown in Table 3. The emissions from ICE vehicles in Germany and Sweden are also given, together with data from a report published by the Commission of the European Communities for ICE cars in most European countries. From this same report (COST 302 Committee on Electric Road Vehicles) we also give data for electric cars in Sweden, German and the UK.[1] For comparison, the new EEC standard for cars over 2L is shown, together with estimates for a car with a catalytic convertor and an electric car in Germany when flue gas desulphurisation plants have been installed as well as catalytic convertors to remove the nitrogen oxides from power station emissions.[4]

While we appreciate the fact that we in the UK are beginning to install flue gas desulphurisation plants in our power stations, we would like the UK to speed up the process, as in Germany, so that when we introduce fleets of electric road vehicles, they will not only contribute to a cleaner, quieter environment in urban centres, but will also ensure that air pollution is reduced to the absolute minimum. In this respect, we would also welcome the use wherever possible of combined heat and power, as more efficient use of fuel will of course reduce the emissions generated.

It should be emphasised that these figures are approximate and depend upon the data supplied by each country. In the case of our own country, the Government figure for carbon monoxide emitted during 1980 from all sources has been reduced from 7930 to 5127 thousand tonnes. We should also bear in mind, that in order to give a fair comparison with electric vehicles, where the pollution is caused by the fuel supply infrastructure, the European Commission's report allocates a proportion of the hydrocarbons emitted by the fuel supply infrastructure to each ICE car. The electric car in Sweden already illustrates the tremendous advantages of using natural energy resources, but we should consider that they also have their own associated environmental difficulties and other countries do not have the same resources. The projected emissions given for an electric car refer to 44% use of natural and nuclear energy in Germany when the coal-fired plants have installed flue gas desulphurisation and catalysts to remove nitrogen oxides. The ICE car with catalytic convertor will continue to emit other forms of pollutants, although in much reduced quantities, and we should equally bear in mind that natural and nuclear energy may have adverse effects, and it is important to quantify these as acccurately as possible, while at the same time minimising the problem by conserving energy wherever possible. Natural energy sources, from wave, wind and solar power can be utilised directly, and therefore most effectively, by electric vehicles. One interesting development, which could be used in warm climates is the solar powered car which has successfully completed several thousand miles evaluation.[5] Another method of improving the environment, which is perhaps more appropriate in the

UK, is to introduce fleets of electric powered trams, trolleybuses, light rail or metro systems, which cause no pollution in their immediate vicinity, reduce overall national emissions, use much less fuel per passenger mile travelled and help to eliminate the traffic congestion which is a major cause of pollution, by providing a clean, quiet, efficient service.

INTERNATIONAL ELECTRIC VEHICLE PROGRAMMES

While in the UK the development of electric vehicles has sadly declined in the past few years, overseas it is progressing in many countries. The USA in particular is planning to introduce between 5,000 and 10,000 battery electric vans into urban fleets during the next few years. Our own UK development of the Lucas/Chloride vans has transferred to the USA, where it will be financed by the US Government, although Chloride will still keep the UK programme going in conjunction with the Southern Electricity Board, which is operating a fleet of vans. The smaller Government sponsored project with Hawker Siddeley ceased some time ago, but I understand that some of the benefits of this technology will be transmitted to India under a licensing arrangement supported by the Indian Government. The Japanese have of course completed many prototype electric vehicles and are prepared to manufacture them on a massive scale as soon as the combined effects of oil price rises and Government measures to reduce traffic emissions make electric vehicles commercially competitive in more than the present limited applications. Several other countries, in the Pacific Basin and South America are preparing to manufacture electric cars and vans.

Here in Europe, several car manufacturers are making batches of electric vehicles, and the Commission of the European Communities is actively seeking ways to encourage their use.[1] There are already small towns in Europe, such as Zermatt, where ICE vehicles are excluded and only electric vehicles are allowed. The Commission realises that this would be impracticable in many large towns, but recommends several ways in which local authorities could encourage the greater use of electric and other forms of low-polluting transport.

1) The creation of designated areas which are reserved for the exclusive use of EVs, together with public transportation and bicycles.
2) Issue special parking permits for EVs in areas where the use of conventional vehicles is limited and parking severely restricted.
3) Generalisation of regulations which oblige ICEVs to turn off their engines when they stop (this is favourable for electric distribution vans).
4) Establish parking lots in the outskirts of the city (rather than in the centre) and connect to the centre by public transportation, electric urban taxis and possibly electric cars for hire.
5) Electrify public transport as much as possible, ie put into operation battery minibuses, trolleybuses of normal size, rail systems and/or automated guideway transits. This would make more perceivable the quietness of, and the absence of pollution from, the EVs.
6) Allow heavy vehicles, eg garbage collection trucks and delivery lorries, in the central parts of the town only when they are electrically propelled.
7) Also for lighter goods distribution, electric propulsion would be required in central urban areas.
8) Replace a good proportion of the ICEVs in the local administration's own fleets by EVs.
9) Use electric vehicles for local duties in and around railway stations and airports.
10) Provide, free of charge to users, special local facilities for overnight charging in some vehicle parks for vehicles which cannot be recharged where they are normally kept, and for opportunity charging during the day.
11) Establish community bodies for the marketing of EVs of different makes, for maintenance and repair of EVs, for the distribution of necessary ancillary products (eg distilled water) and for the education of drivers and fleet supervisors.
12) Modify local regulations, for instance as regards gross weight, speed and use, in favour of EVs when this would not affect safety.

COSTS OF EMISSIONS

The Commission report estimated that the cost benefit to the community, in terms of reduced air pollution alone, of one electric vehicle, ranged from £150 to £485 per annum [1], depending upon the country concerned and the type of vehicle, as illustrated in Figure 1. This represents a very substantial saving to the community, and it would seem reasonable that, as the Commission recommends, national Governments should make tax allowances for electric vehicles to reflect this benefit. As we are all aware, the cost of pollution is extremely high in terms of damage to human life, plants, trees, other animals, buildings and possible accident or climatic change.

The OECD estimates that about 1% to 2% of the gross national product of industrialised countries is spent on alleviating the problems of pollution [2], and it is considered that money would be better spent on eliminating the problem as far as possible in the first place. For instance, the Building Research Establishment estimates that it would cost several hundred billion pounds to protect all vulnerable buildings. The Environmental Protection Agency in America estimates that ozone alone causes reduced crop yields of $2 to $4 billion every year. In Germany, the Association of Forest Owners estimated annual losses at £250 to £300 million several years ago. There has been little attempt to assess the damage to animal life, but it is essential that more data is made available on all these aspects as soon as possible so that we can take effective action.

Several European Governments, including our own, have reduced the tax burden on electric vehicles, but this is partly offset by the greater amount of VAT which is payable on electric cars, which are produced in small quantities and therefore cost about 50% more than a comparable ICE car. The main tax advantage for electric vehicles has occurred quite accidentally, as there is no tax on electricity, but this state of affairs would be unlikely to continue if large numbers of electric vehicles were in use. We feel that our own Government is not taking strong enough action to encourage the new technologies which will improve our

environment. It is significant perhaps that out of the 63 representatives from 24 countries on the OECD Committee for Transport and the Environment, which published a report earlier this year, the UK was the only major country without a delegate. In view of the Government's cutbacks on local authority spending, it would have been wise to have at least continued the small annual grants and subsidies given to manufacturers and operators of electric vehicles. In this respect we would also welcome a new initiative from British manufacturers. As one of the manufacturing members of my own Group, the EVDG, said recently, clean technology is the technology of the future, and we in Britain are already conceding the lead to Germany and Japan.

NEW ELECTRIC VEHICLE TECHNOLOGIES

The main reason why electric vehicles are not used more widely is because of the range limitation, and in order to overcome this problem, several different types of hybrid electric vehicle have been designed. There are two basic1 design concepts, the simplest is that an IC engine is used as a range extender for a battery electric vehicle, so that the benefits of clean, quiet electric drive can be achieved in city centres. The second, which my own Group is pursuing, is that a small IC engine (we use a 1.6L diesel in a full size Transit van) operates at its constant optimum speed in its most efficient mode, while the electric motor does all the hard work of providing the peak power. The waste energy from the engine, and that regenerated when braking, is put back into a small bank of automotive batteries, so that external electricity charging is not generally required. In terms of emission reduction, the engine can be operated in its most efficient and non-polluting mode, fuel is reduced, and there is the additional advantage than in environmentally sensitive areas, the vehicle can be powered at medium speed by the batteries alone. This adds greatly to the comfort of the driver, who can sit quietly, without any juddering from the engine, or fumes, in a traffic jam, and simply switch on the engine when he wants to increase speed to over 30 mph.

Some scientists believe that it will be essential to use electricity or perhaps hydrogen for road vehicles because of the long term problems which could be caused by burning

fossil fuels.[6] My group also strongly supports the development of fuel cells, which would utilise methanol or possibly hydrogen for future electric vehicles. Although these fuels could be used in IC engines, the fuel cell is much more efficient and causes minimal pollution. One interesting possibility, which could be used in both industrial and developing countries, is that waste land could be planted with trees, which would provide methanol for local transport needs.[7] Although there would continue to be some carbon dioxide emissions, they would be countered to some extent by the additional tree population.

Although the UK funded programmes with fuel cells have ceased, the Commission of the European Communities has started a new research project, in which a British team is participating, and several other European countries are stepping up their work in this field. The international leader in this field is Japan, which has several prototype power plants for generating electricity, and is also developing a methanol fuel cell for road vehicles. The USA is also developing fuel cells, and of particular interest is a recent initiative by their Departments of Energy and Transportation for a fuel cell/battery powered bus system, which can provide the range of an IC engine but with clean and quiet operation, using non-petroleum based fuels.[8]

NOISE POLLUTION

Noise is considered to be a problem by the majority of people who live in towns, and traffic noise is the main offender. Noise is a major factor in causing stress and related illnesses. Noise also interferes with communications, so that speech, music and other sounds may be difficult to distinguish. The OECD has recommended that noise limits should be lowered for road vehicles, and estimates that this would cost approximately an additional 5% of the purchase price for most vehicles.[1] In order to reverse the present trend for increased noise from traffic, they propose that the noise level for a passenger car, measured at 7.5 metres from the accelerating vehicle, should be reduced from 80 to 75 dB(A). The reduction of permissible levels for vehicle noise should be backed up with a series of measures in such areas as infrastructure, town planning, habitat and individual

behaviour patterns. One possibility would be to exclude noisy vehicles afrom environmentally sensitive areas, and this would provide an added incentive to manufacture and use quiet vehicles, which could be electric powered.

Figure 2 illustrates noise levels from traffic in relation to that from other sources. For comparative purposes, data for electric and IC engined cars has been obtained from Germany, where Volkswagen Golf cars have been evaluated in petrol, diesel and electric powered forms.[9] The measurements were taken to ascertain the level of noise experienced by the driver, but they do of course give a good indication of the sound heard by other road users. When standing still, that is in traffic jams, for instance, the noise levels for the petrol, diesel and electric Golf respectively were 77, 78 and 58 dB(A). During different states of operation, from cruising up to accelerating, noise levels varied from 68-84 dB(A) for the petrol Golf, 69-79 dB(A) for the diesel car and only 60-66 dB(A) for the electric Golf.

CONCLUSION

We need to develop electric vehicle technologies as a matter of urgency, in order to meet the growing international demand for vehicles which are clean, quiet and not dependent upon oil. This technology is a field in which the UK has traditionally been in the forefront, and a strong initiative is needed to retrieve the lead from competitors such as Germany and Japan. Electric vehicles, whether they are powered by batteries, fuel cells or from wayside electricity supplies, could enable us in the UK to make the most efficient use of national energy resources, and at the same time improve the quality of life in our crowded city centres.

References

1) Commission of the European Communities, COST 302 Report on Electric Vehicles, Luxembourg, 1987

2) OECD, Transport and the Environment, Paris, 1988

3) House of Commons, Environment Committee, Air Pollution, HMSO 1988

4) B. Sporckmann, Electric Vehicle Developments, London, July 1988

5) Electric Vehicle Developments, January & July 1988, London

6) AVERE Report, Electric Vehicle Developments, July 1988, London

7) O. Lindstrom, Fuel Cell Technology and Applications, Netherlands Agency for Energy and the Environment, 1987

8) P. G. Patil, US Department of Energy, Eighth Battery and Electrochemical Contractors Conference, 1987, Washington

9) D. Kraft, K-H Stracke, E. Zander, Seventh International Symposium on Electric Road Vehicles, Paris, 1984

TABLE (1) Car exhaust gas composition during ECE cycle

SUBSTANCE	CHEMICAL FORMULA	GRAMS/LITRE
NITROGEN	N_2	8568
CARBON DIOXIDE	CO_2	2019
WATER VAPOUR	H_2O	990
CARBON MONOXIDE	CO	167
OXYGEN	O_2	130
HYDROCARBONS	HC	15
OXIDES OF NITROGEN	NO_x	12.6
HYDROGEN	H_2	4.2
ALDEHYDE	$HCHO$	0.254
SULPHUR DIOXIDE	SO_2	0.244
LEAD COMPOUNDS	Pb	0.075
SULPHATES	SO_4	0.017
AMMONIA	NH_3	0.011

TABLE (2) MAN-MADE EMISSIONS: CONTRIBUTION FROM TRANSPORT

SELECTED COUNTRIES 1980 [2]

	TOTAL:THOUSAND TONNES/ ANNUM				TRANSPORT:THOUSAND TONNES/ANNUM (% TOTAL)			
	SO2	NOx	CO	HC	SO2	NOx	CO	HC
Canada	4650	1942	9928	2100	140(3%)	1282(66%)	7347(74%)	840(40%)
USA	23200	20300	76000	22800	928(4%)	9135(45%)	53200(70%)	9120(40%)
Germany	3200	3090	8960	1860	128(4%)	1638(53%)	5824(65%)	707(38%)
Nether-lands	445	500	1368	452	18(4%)	265(53%)	985(72%)	100(22%)
Norway	141	125	632	158	18(13%)	100(80%)	499(79%)	70(44%)
Sweden	483	328	1250	410	24(5%)	203(62%)	1225(98%)	230(56%)
UK	4670	1932	5127	1954	47(1%)	560(29%)	4563(89%)	313(16%)

TABLE 3 COMPARATIVE EMISSIONS: I.C.E./ ELECTRIC CAR

GRAMS/ KILOMETRE

	CARBON MONOXIDE	SULPHUR DIOXIDE	NITROGEN OXIDES	HYDRO-CARBONS
PRESENT EMISSIONS				
I.C.E. cars:				
UK	16.3	0.16	2.0	1.12
Germany	16.0	0.35	4.5	1.95
Sweden	26.6	0.52	4.4	5.0
European Commission report	26.0	0.12	1.7	2.94
New EEC standard	6.2	-	0.8	0.8
Electric Cars:				
UK	-	3.07	1.01	-
Germany	0.024	1.66	0.79	0.006
Sweden	-	0.08	0.03	-
PROJECTED EMISSIONS				
I.C.E. Vehicle with catalytic convertor (estimates vary)	1.2 to 2.1	-	0.41	0.17 to 0.21
Electric car (with cleaner power stations)	.024	0.14	0.14	0.006

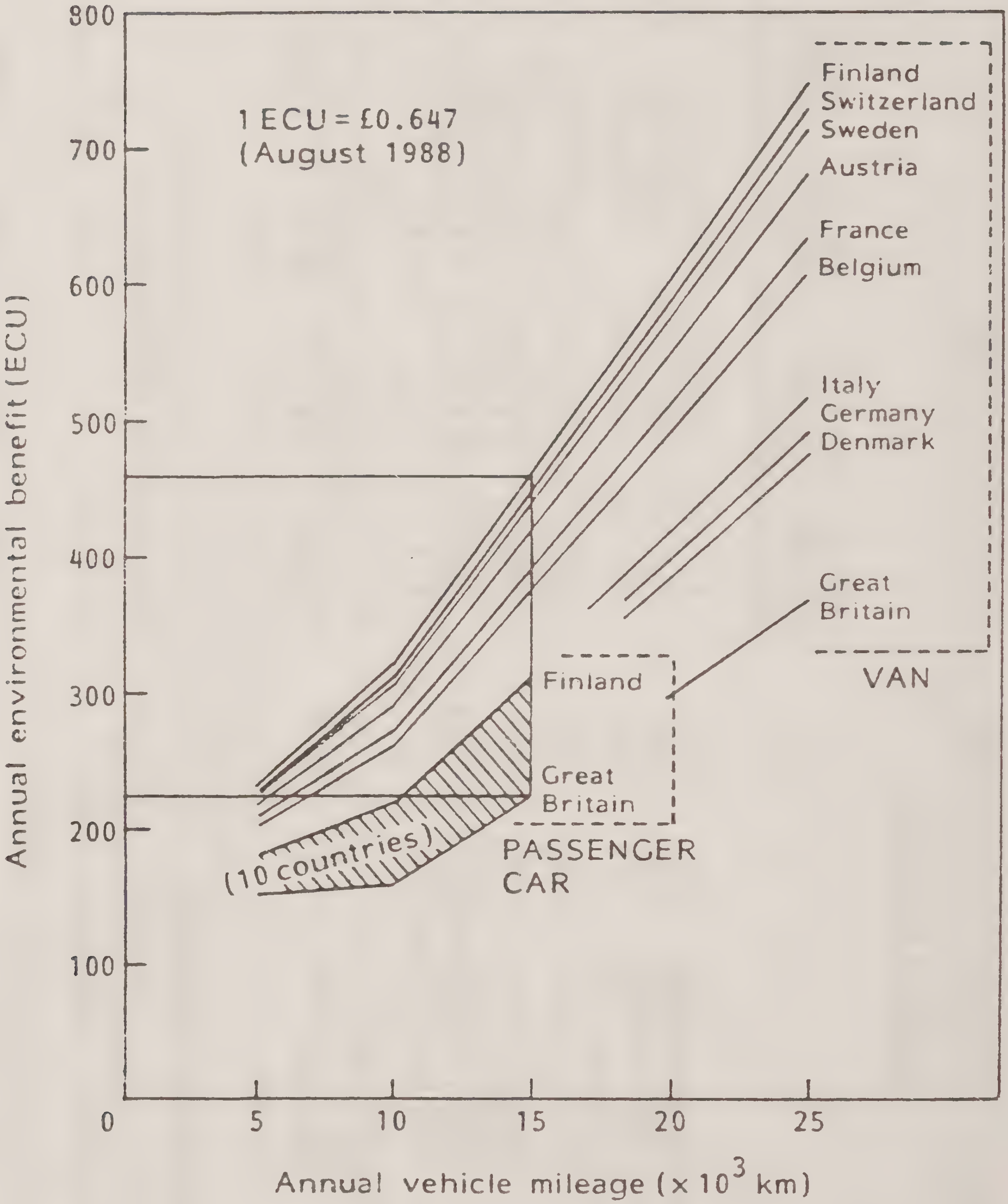

FIG (1) Annual environmental cost benefit of an electric car and an electric van.

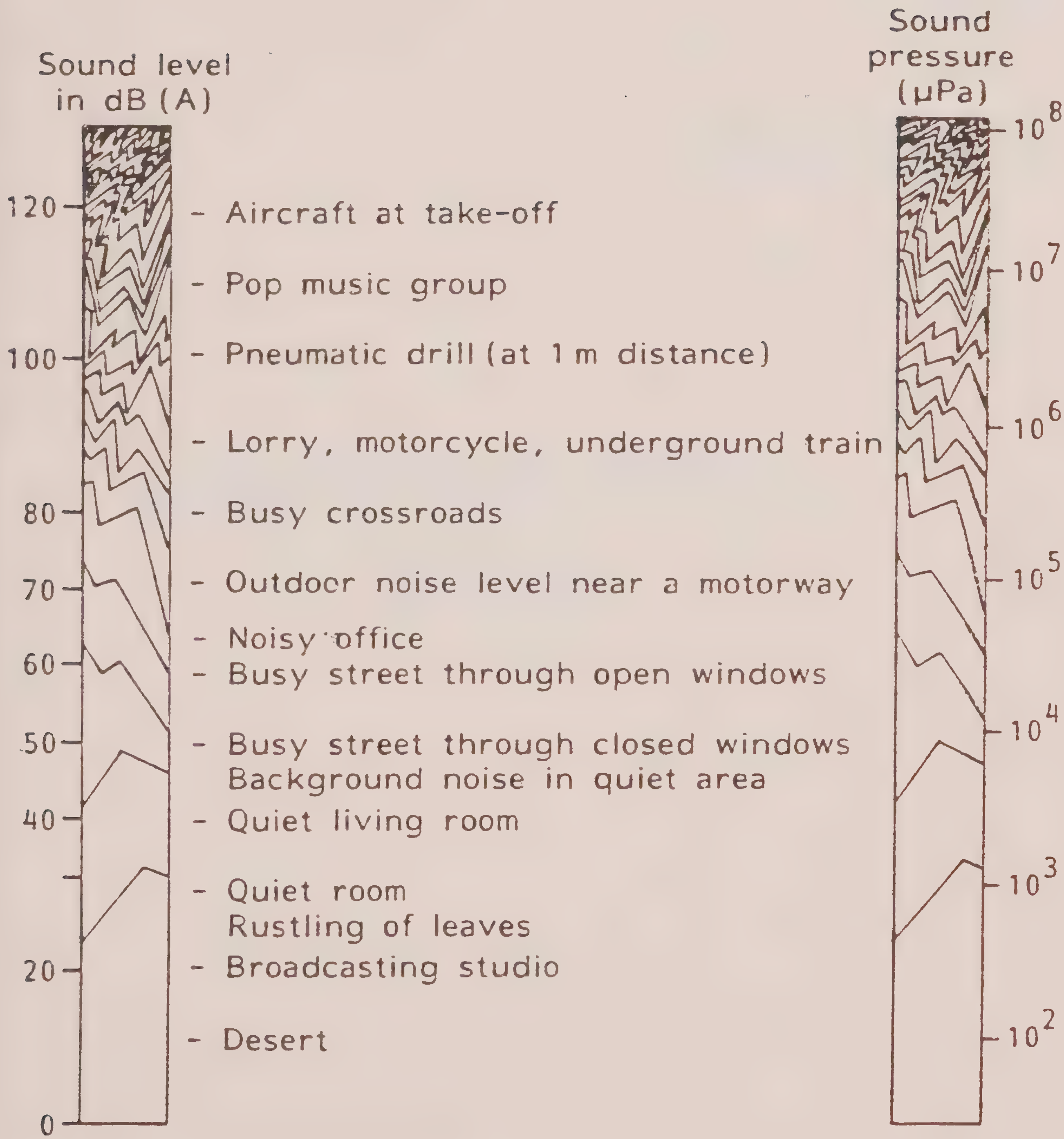

FIG 2. EXAMPLES OF NOISE LEVELS

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SESSION 5

AIR POLLUTION CONTROL
SITUATIONS REPORT - PART II

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MONERAL FIBRES AND HEALTH

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Asbestos has been known to be a hazard to health since the beginning of this century and asbestosis was described in 1927[1]. Subsequently, exposure to respirable asbestos dust was shown in the 1930s to cause lung cancer[2] and in 1960 to cause mesothelioma[3]. There is no dispute that asbestos causes disability, disease and death.

Current attention is focused on the differentiation between the different types of asbestos in terms of risk to health. In particular, is chrysotile (white) asbestos as dangerous as crocidolite and amosite? Can occupational and environmental controls be set to permit the use of chrysotile safely?

Substitutes for asbestos have been available for many years. These include several mineral fibres man-made from glass, rock and slag. Ceramic fibres are also being used but to a much lesser extent. Up to 1972, there was almost universal scientific acceptance that these fibres were not hazardous to health. But in 1972, animal experiments were published[4,5] which showed that under experimental conditions which bypassed normal body defences, these man-made mineral fibres caused mesotheliomas. Since then considerable effort has been invested in the study of workers in the man-made mineral fibre production industry to seek evidence of excess mortality or cancer incidence. The results remain inconclusive.

More recent observations in Turkey of very high mesothelioma mortality in a remote rural community[6,7] led to the discovery of naturally occurring fibrous zeolite rock. The villagers cut this rock for building blocks and natural dust is widespread, so exposure to the fibres occurred from birth. Several other outcrops of fibrous zeolite have been found worldwide, including one used as a source of material for cat litter, the substance placed in trays so that domestic pets may excrete indoors.

The asbestos minerals

"Asbestos" includes a number of different fibrous minerals with different characteristics and properties. Crocidolite (blue

asbestos), amosite (brown) and tremolite are all amphiboles. These are typically fine, rigid and straight fibres which can easily be deposited in the lung and which survive there for decades. Chrysotile (white asbestos) fibres are also fine, but are curly and flexible. They split easily into ultra-fine fibrils which can only be detected in the lung by electron microscopy. Their shape prevents their deposition in the lungs as readily as the amphiboles and they are also eliminated, particularly by physicochemical dissolution.

The general acceptance that chrysotile is less harmful to health than the amphiboles is most clearly seen in the asbestos exposure control limits, which are set more stringently for the amphiboles in many countries, including the UK. Unfortunately there are few studies of exposure to asbestos for which dose-response relations are available, because of the paucity of environmental hygiene measurements before 1970 and of adequate individual occupational histories[8,9]. The slopes of the dose-response relations that have been determined vary considerably with industrial process and fibre type.

One example that undoubtedly demonstrates that crocidolite exposure is far more harmful than chrysotile exposure is the study of mortality of the women who manufactured gas masks during the second world war. Many of those using crocidolite, for Forces masks, died from mesothelioma, unlike their colleagues who used chrysotile to manufacture civilian gas masks[10].

Many studies are now being undertaken of the fibre content of lungs. These show that those who died from asbesos-related diseases tend to have higher numbers of amphibole asbestos fibres in their lungs and also that the chrysotile fibre content is unrelated to cause of death[11]. A similar study compared the lung fibre burden of chrysotile miners in Thetford Mines, Quebec, of residents of that town and of Vancouver residents. The Thetford Mines residents suffered ambient exposure to chrysotile 200 to 500 times higher than in other North American cities, had lung burdens some 10 times higher (and with longer fibres) than the Vancouver residents, and yet showed no evidence of excess mortality[12]. It was concluded that

" substantially higher burdens of, and considerably longer and higher aspect ratio fibres of, chrysotile and tremolite than those to which the general population are exposed can be tolerated for long periods (even lifetimes) of continuous exposure with no obvious harm. These observations should provide reassurance that exposure to chrysotile asbestos from urban air or in public buildings will not produce detectable disease."

Man-made mineral fibres

The animal experiments published in 1972[4,5] involved implanting various materials into the pleural cavity of rats to determine which would cause mesothelioma of the pleura. Not surprisingly, all types of asbestos proved positive. But unexpectedly then, so did many of the man-made mineral fibres. These experiments showed conclusively that the mesothelioma rate was related to length of fibre (particularly greater than 8 m) and to its diameter (less than 0.25 m).

Although there was then no firm human evidence that man-made mineral fibres could cause disease, major European and American studies were set up to investigate the mortality of workers in the production industry. It was also possible to investigate cancer incidence for some of the European plants. A similar smaller study was set up in Ontario, Canada.

Epidemiological Studies - Description

<u>European study</u>

The European study involved national investigators in seven countries, coordinated at the International Agency for Research on Cancer. This study started in 1976, funded by the European trade associations through a British charity, the Joint European Medical Research Board.

Although there were 72 production plants in Europe, only 13 could be included in the study because of limitations on the availability of essential information, possible exposures to asbestos and too short a production period. In particular, no

French plant could be included as individual mortality details were not available for medical research, as part of national practice. This excluded the largest plant, with excellent personnel records.

For the latest publication[13], the 21,967 production workers were followed up as detailed in Table 1. Both mortality and cancer incidence were studied for the first nine plants. The Italian plant (13) changed its process in 1960/61 from glass wool to continuous filament production. All workers were included, except in England and Sweden where there was a requirement to have had at least one year of employment.

The average length of follow-up was 16 years for those in rock and/or slag wool production (46% of the cohort), 18 years for glass wool production (38%) and 16 years for continuous filament (16%). The study group included 3214 women (15%) and almost all the published results refer to both sexes combined. Mortality was compared to expected death rates based on national vital statistics. For lung cancer only, the resulting national Standardised Mortality Ratios (SMR) were adjusted for local or regional variations to estimate 'local' SMRs. The results presented here are based on the local rates, for those analyses of lung cancer only.

Assessments were made of dust exposure levels by collaborators from the Institute of Occupational Medicine, Edinburgh[14,15]. Current (1977-1980) exposure levels were low, with mean values of 0.06 f/ml in the rock wool plants and 0.03 f/ml in the glass wool plants. In the secondary production of fine glass fibres, average concentrations reached 1 f/ml.

In determining the dust exposure levels in previous years, three technological phases of production were recognised:

Early:	No dust suppression used, mineral oil binders usually and/or labour intensive, hand operated batch production.
Intermediate:	Mixed early and late.

Late: Modern mechanised production methods, with oil and resin binders.

For rock wool production, airborne fibre concentrations in the early technological phase were estimated to be 1-2 f/ml, with the dustiest values being about 10 f/ml. For glass wool, the estimated values were similar to the 1980 concentrations.

American study

Although this study was limited to one country, it also covered a large number (17) of man-made mineral fibre production plants[16]. Since the published paper, a final report[17] has been presented to the American trade association which funded the research. The results presented in this paper are taken from this final report.

Unlike the European study, the major component of the American study was concerned with glass fibre and continuous filament (termed fibrous glass). Eleven of the plants and 89% of the 16,661 study group worked in fibrous glass production. The start of production ranged from 1938 to 1952 compared with 1929 to 1948 for the mineral wool (that is rock and/or slag wool) plants.

The cohort consisted of all men with one or more years of production or maintenance work between 1945-1963, with one minor exception of a 1940 starting date. The one year limit was reduced to six months at two plants where fine glass fibres were being produced. Follow-up was until the end of 1982. The period of follow-up averaged 26 years for both the fibrous glass and the mineral wool workers. Thus although the cohort was slightly smaller than the European, the much longer follow-up means that the American study provides rather more information about the extent of risk associated with exposure to man-made mineral fibres.

The observed mortality was compared with that expected for all US white males (national SMRs) and with expectation based on the mortality experience of white males in the counties in which the plants were situated (local SMRs). As for the European study, the results presented here are based on the local SMRs, when available.

The American investigators also undertook a case-referent study to compare smoking habits of those who died of lung cancer or non-malignant respiratory disease (other than influenza and pneumonia) with a random sample of all workers.

Airborne man-made mineral fibre concentrations were determined by special sampling studies in most of the plants and then exposure levels estimated for each job in each plant since its start date[18,19]. This permitted estimation of the total fibre exposure for each individual. For fibrous glass it was estimated that fibre concentrations had not changed, except in 7 of 27 departments in two plants. This conclusion agrees with that in the European study, and fibre levels are similar, being 0.07 f/ml or less in 10 of the 11 plants. For one plant which produced fine glass fibres, the exposure level was estimated as 0.3 f/ml. For mineral wool, the exposure estimates were 1.5 f/ml prior to 1945, 0.3 f/ml for 1945–1960 and 0.03 f/ml since then.

Canadian study

One Ontario plant producing insulating glass wool was studied[20]. All 2557 men who had worked at least 90 days between 1955 and 1984 were included. The average follow-up was 19 years. The men were classified into three groups: plant workers only; office workers only; mixed exposure.

Exposure levels were estimated from hygiene surveys taken since 1978. The fibre levels were rarely above 0.2 f/ml with mean levels substantially lower. The authors report, anecdotally, that past dust concentrations were higher.

Epidemiological Studies - Results

Follow-up in all three studies was high, being 98%, 97% and 97% in the European, American and Canadian studies respectively.

Overall mortality was significantly raised in the European study (SMR=111 with 95% confidence interval 107–115). For the American study the SMR was 102 (95% ci 99–105) and

for the Canadian study, the SMR was significantly lower than expected (SMR=84).

If man-made mineral fibres are analogous to asbestos in being hazardous to health, then excess mortality from mesothelioma, lung cancer and non-malignant respiratory diseases would be expected. Any such excess would also be expected to appear many years after the start of exposure in the man-made mineral fibre production industry. Any evidence showing that the higher the exposure the greater the risk would tend to support the view that man-made mineral fibres are hazardous to health, although there may be other causal concomitant exposures.

One case of mesothelioma was reported for the European study and three for the American. The European man had only worked for 2 years in this production industry and died 13 years after first employment. It is very rare for mesothelioma to occur less than 20 years after first exposure to asbestos, so this case is most unlikely to have been caused by his exposure to man-made mineral fibres. The US Mesothelioma Reference Panel rejected the first case unanimously. Tissue specimens were not available for either of the other two cases, and one did not have a complete employment record. The other, who died in 1980, worked in a Navy shipyard from 1940 to 1941, so asbestos exposure is possible. He worked in the production of fine fibres from 1954 to 1958, so this exposure is less likely to have been causal, although the latent periods of 26 years or less do occur following amphibole asbestos exposure. One or two mesothelioma deaths in a total of over 840,000 person-years of observation agrees well with expectation for people not occupationally exposed to asbestos[21].

Mortality in the European study

As shown in Table 2, the overall mortality was significantly raised but most of the excess was restricted to those who had worked in man-made mineral fibre production for less than one year. If this had been a criterion for inclusion, as in the American study, then the SMRs would have been identical. Workers with less than one year of employment were included for 9 of the 13 plants and totalled about one

in three of the study group. They had excess mortality from a number of causes, particularly from accidents, poisoning and violence (ICD codes E800-E999). They also showed excess mortality from diseases of the respiratory, nervous and digestive systems and from cirrhosis of the liver.

There is no pattern in the relation between total mortality and years since first exposure to man-made mineral fibres, duration of exposure or any other exposure parameter studied. This is also true for all malignant neoplasms, other than of the trachea, bronchus and lung (lung cancer), and for non-malignant respiratory diseases.

About half the excess of malignant neoplasms could be accounted for by the excess of lung cancers. No other malignant neoplasm showed a significantly raised rate. Table 3 shows the relation between years since first exposure to man-made mineral fibres and mortality from lung cancer and from non-malignant respiratory disease. The lung cancer mortality shows a marked trend with years since first exposure, reaching a significant excess for those followed up for more than 30 years. The non-malignant respiratory disease mortality also shows a trend, but no single SMR is significantly different from 100.

In Table 4, the lung cancer deaths are considered in relation to the type of fibre produced. For both rock/slag wool and glass wool, the SMRs rise with the length of time since first exposure, particularly for the 30+ group. The numbers of deaths are small in each group, so none of the SMRs reaches conventional levels of statistical significance. (It should be noted that for glass wool, based on national death rates, the SMR for the 30+ group was significantly higher than 100.) The production of continuous filament is too recent for there to be many people with more than 20 years since first exposure. There were no lung cancer deaths in these groups, compared with less than 3 expected.

To explore the relation between lung cancer mortality and exposure further, the SMRs have been related to the technological phase of production. As this analysis is based on duration since first exposure, the workers have been allotted to the production phase pertaining when they were

first exposed. The analysis for the rock and slag wool producers is shown in Table 5. Although the deaths were few, the SMRs are highest for the early phase and lowest for the late phase. For the glass wool workers there is no clear pattern between mortality and technological phase.

Some estimate of the possible effects of other substances present during the production of man-made mineral fibres could be made, using knowledge of the years during which these substances were in use. The authors present evidence for slag, bitumen, asbestos and formaldehyde. Table 6 summarises this evidence for slag, bitumen and asbestos in slag and rock wool production. The SMRs for lung cancer are markedly raised for those exposed to slag, a material recognised to be causative of lung cancer because it often contains arsenic. Surprisingly, it was those not exposed to asbestos for whom the SMR was raised. There was no evidence of an association with bitumen in this group. For those producing glass fibres, there was no association with either bitumen or asbestos use and overall there was no association with formaldehyde usage.

Cancer incidence in the European study

It was possible to study cancer incidence for nine of the 13 plants using national cancer registry information to calculate the expected numbers of cancers. The Standardised Incidence Rate (SIR) for all cancers was 101 (95% confidence interval 93-110). The only cause for which it was significantly raised was Cancer of the Buccal cavity, Pharynx, (SIR = 153, 95% ci 100-224), based on 26 cases. For this cause there was a trend with time since first exposure.

For lung cancer, the SIR overall was 116 (95% ci 93-143) with the excess limited to the rock/slag wool workers. However the two largest glass wool plants were excluded because no cancer incidence data were available. The SIR rose with increasing years since first exposure as shown in Table 7.

Mortality in the American study

Table 8 presents the overall mortality for the American

cohort. Compared with the European study (Table 2), standardised mortality is generally lower, except for non-malignant respiratory diseases (excluding influenza and pneumonia). There is a significant deficit of violent deaths, in absolute contrast to the European result, but for most American plants those employed for less than one year were excluded.

It should be noted that the overall death rate, compared to expected based on national vital statistics, was rather higher in the last five years of the study than in earlier periods. The same holds for all malignant neoplasms and for lung cancer.

In this study, separate analysis has been made of the relation between respiratory cancer (rather than with lung cancer, as in the European study) and measures of exposure. Lung cancer accounted for 96% of all respiratory cancers, the balance being mainly laryngeal cancer.

Table 9 shows that respiratory cancer mortality is raised for the mineral wool producers, but independent of time since first exposure. There is some indication of an excess among those first employed in glass wool production more than 30 years ago. However, respiratory cancer appears to be unrelated to duration of exposure to man-made mineral fibres, except that the SMRs are highest for the mineral wool workers with the shortest employment history.

In four of the 17 plants, fine glass fibres were produced. Table 9 shows that even though there were few respiratory cancer deaths among these workers, the SMR for those first employed 30 or more years ago is large.

Several other analyses have been presented by the study team. These show, inter alia, that respiratory cancer SMRs are highest for those men with intermediate total exposures to fibres, based on the individual estimates of fibre exposure. For the highest exposed people, the fibrous glass and mineral wool SMRs are 101 and 100 respectively.

Non-malignant respiratory disease does not appear to be related to fibre type or to time since first exposure (Table

10). Those ever exposed to fine glass fibre many years ago perhaps have a raised death rate but the number of deaths is too small to draw any firm conclusion.

In the case-referent study to assess the effects of smoking, interviews were attempted for 390 respiratory cancer cases, 225 non-malignant respiratory disease and 596 referents. Interviews were completed for 61% of the cases and 70% of the referents.

Several analyses to separate the effects of smoking and exposure were undertaken. These analyses all show that cigarette smoking contributes most to the deaths from respiratory cancer and from non-malignant respiratory disease. For the fibre glass workers, age was also a highly significant factor, but no measure of exposure contributed to the prediction of mortality.

Among the mineral wool workers, respiratory cancer was unrelated to age but was related to time-weighted average exposure to fibres. Non-malignant respiratory disease was not related to either age or exposure in one analysis, but was related to both in another, in which case the exposure predicted a reduction of risk with increasing exposure. The number of cases on which these analyses were based is small, and it is probable that the high correlation between age and time-weighted exposure prevents effective separation analytically of their contributions to mortality.

<u>Mortality in the Canadian study</u>

In this study, 157 men died compared with 188 expected, a significant deficiency of deaths (Table 11). The analyses suggested that this deficit was due to the 'healthy worker effect' as it disappeared after 20 years of follow-up.

Lung cancer was the only cause for which there was evidence of excess mortality, whether considering all members of the study group or just those who had only worked in the production plant.

Table 12 shows that this excess lung cancer mortality was unrelated to time since first exposure to glass wool. Further

analyses taking into account duration of exposure showed that the highest SMR occurred for those with the shortest duration of exposure and the shortest time since first exposure (although the numbers were too small to ascribe much confidence to this finding).

Smoking histories were not available, but the authors argue that the excess lung cancer mortality was too great to be attributable solely to smoking. They noted that four of the cases among the plant workers occurred among men with less than one year's exposure, so they would have been excluded from the American study.

Other natural fibres

The present concern is with naturally occurring zeolite fibres and the evidence of fibrosis and mesothelioma in communities exposed. With the exception of asbestos, no other fibre has been implicated in the production of mesothelioma in humans.

In central Cappadocia, Turkey, 55 out of about 700 inhabitants of Karain died between 1970 and 1974[6]. Mesothelioma accounted for 44% of these deaths, whereas no such deaths occurred in neighbouring villages, except for cases among migrants from Karain. The local saying is that "the peasant of Karain falls ill with pain in the chest and belly, the shoulder droops, and he dies".

Between 1979 and 1983, an extensive study of Karain and two other villages was undertaken[7]. The environmental survey showed higher levels of zeolite fibres in the environment of Karain, but the differences were not as definite for fibre pollution as for disease. The fibre concentrations ranged up to 0.31 f/ml in Karain, of which 80% were zeolite. In other villages, the values were usually much lower, but one value of 1 f/ml occurred. About 40% of all fibres were less than 0.5 m in diameter.

The authors suggest that exposure was probably much higher twenty and more years ago, when the community used to cut the fibre-bearing rock for building blocks, whereas bricks are now commonly used.

There have been suggestions that some of the adsorbent zeolites used for cat litter have been heavily contaminated with fibres, with resulting mesothelioma risk to the cats. Indeed, a cat (inherited by this author) which had been a cat litter user all its life died in a manner very suggestive of mesothelioma. However, experiments with some of these materials provided unconvincing evidence of a mesothelioma risk[22].

Discussion

This review has concentrated primarily on the epidemiological evidence about the health effects of man-made mineral fibres, because of the rising public anxiety about the possible health effects of materials being used as replacements for asbestos.

Simple analogy suggests that if asbestos fibres are hazardous to health, so must be other fibres. Such analogy omits information about the characteristics of fibres which are known to relate to their harmfulness. To be biologically active in the lung, fibres must be fine and long. They must survive both the effects of movement of the lung, which may fracture fibres transversely, and attack by biological fluids, which may dissolve them. They must also be of a form that can be inspired deep enough tobe deposited in the small airways, although there are suggestions that coarser fibres retained at airway bifurcations may trigger bronchial carcinoma. Other characteristics of importance include the surface activity of the fibres, in that the presence of free radicals could lead to greater adsorbtivity for other airborne carcinogens and to more opportunity to react with the lung. The importance of surface activity is not yet defined, but it should be noted that the risk of lung cancer following joint exposure to asbestos and cigarette smoke is the product of the separate risks[23]. For heavy joint exposure, the risk of lung cancer is increased 50-fold, compared with fivefold for asbestos exposure and tenfold for cigarette smoking. It is possible that asbestos fibres deposited in the lung retain the cigarette carcinogens on their surface and so enhance the carcinogenic effect.

Compared to asbestos, rock and glass fibres are rather thicker and less long. They are not durable in the lung, as they easily break transversely into fragments shorter than 5 m, which can readily be eliminated by phagocyte. They dissolve in lung fluids, unlike the amphibole asbestos fibres.

Yet, there are more deaths than expected from lung cancer in all three epidemiological studies considered above. This excess occurs even though the fibre exposures are believed to have been low. If the excess is caused by exposure to fibres, then it must be concluded that rock and glass wool fibres are much more hazardous than chrysotile asbestos[24]. But, there is no association of lung cancer mortality with fibre concentration or with duration of employment in the production industry. The mesothelioma mortality would have been expected to have been much higher than the two or three that have occurred. Animal experiments involving inhalation have not yielded positive results, but it is difficult to create dust clouds intense enough for the exposed rats to retain enough fibres for definite results. The International Agency for Research on Cancer classification of rock and glass wool as 'possibly carcinogenic to man' is based primarily on the intrapleural implantation studies in rats.

The assumption that excess lung cancers are caused by man-made mineral fibres only must be modified or rejected[25]. The American study provides some evidence of the importance of smoking, but the necessary data are not available in the European and Canadian studies. Perhaps even more indicative is the finding in the European study of high SMRs for those exposed to slag, enough to account for much of the excess lung cancer mortality. Plans are currently being formulated for a further five-year follow-up of this important European cohort. It will be essential to ensure that exposure to confounders, such as the arsenic in slag, is included in the analysis as far as is possible.

Detailed epidemiological assessment of the European ceramic fibre industry is in progress. The outcome of this study will be particularly important, because many ceramic fibres are more rigid and durable than the rock and glass wool fibres. Similarly, some have expressed more concern about the fine glass fibres used for insulation where light weight is

essential, such as in the aircraft industry. The American study points to the possibility of excess lung cancer mortality in those producing this material.

The user industry must also become aware of the possible hazard, expecially in uncontrolled use in confined spaces. As yet no cohort of mineral wool insulators has been identified, who have not also had some exposure to asbestos. Possibly a prospective cohort study should be started now, but its results would not be available for about twenty years.

Twenty years is an unacceptably long time for an answer, even if not equivocal, to be provided. Good environmental practice requires uncontrolled exposures to be eliminated. Good scientific practice requires the biological mechanisms of action of fibres to be elucidated.

REFERENCES

1. Cooke, W.E. (1927) Pulmonary asbestosis. British Medical Journal, ii, 1024-5.

2. Lynch, K.M. and Smith, W.A. (1935) Pulmonary asbestosis iii. Carcinoma of the lung in asbestos silicosis. American Journal of Cancer, 24, 56-64.

3 Wagner, J.C., Sleggs, C.A. and Marchand, P. (1960) Diffuse pleural mesothelioma and asbestos exposure in the Northwestern Cape Province. British Journal of Industrial Medicine, 17, 260-271.

4. Stanton, M.F. and Wrench, C. (1972) Mechanisms of mesothelioma induction with asbestos and fibrous glass. Journal of the National Cancer Institute, 48, 797-821.

5. Pott, F. and Friedrichs, K.H. (1972) Tumoren der Ratten nach i-P Injektion faserformiger Staube. Naturewissenschaften, 59, 318.

6. Baris, Y.I., Sahin, A.A., Ozesmi, M., Kerse, I., Ozen, E., Kolacan, B., Altinors, M. and Goktepeli, A. (1978) An outbreak of pleural mesothelioma and chronic fibrosing pleurisy in the village of Karain/Urgup in Anatolia. Thorax, 33, 181-192.

7. Baris, I., Simonato, L., Artvinli, M., Pooley, F., Saracci, R., Skidmore, J. and Wagner, C. (1987) Epidemiological and environmental evidence of the health effects of exposure to erionite fibres: a four year study in the Cappadocian region of Turkey. International Journal of Cancer, 39, 10-17.

8. Liddell, F.D.K. and Hanley, J.A. (1985) Relation between asbestos exposure and lung cancer SMRs in occupational cohort studies. British Journal of Industrial Medicine, 42, 389-396.

9. Rossiter, C.E. and McEllison, J. McK. (1986) The current asbestos standards. Occupational Health Review, June/July 1986, 25-29.

10. Acheson, A.D., Gardner, M.J., Pippard, E.C. and Crime, L.P. (1982) Mortality of two groups of women who manufactured gasmasks from chrysotile and crocidolite asbestos: a 40 year follow up. British Journal of Industrial Medicine, 39, 344-348.

11. Wagner, J.C., Moncrieff, C.B., Coles, R., Griffiths, D.M. and Munday, D.E. (1986) Correlation between fibre content of the lungs and disease in naval dockyard workers. British Journal of Industrial Medicine, 43, 391-5.

12. Churg, A. (1986) Lung asbestos content in long-term residents of a chrysotile mining town. American Review of Respiratory Diseases, 134, 125-127.

13. Simonato, L., Fletcher, A.C., Cherrie, J.W., Andersen, A., Bertazzi, P., Charnay, N., Claude, J., Dodgson, J., Esteve, J., Frentzel-Beyme, R., Gardner, M.J., Jensen, O., Olsen, J., Teppo, L., Winkelmann, R., Westerholm, P., Winter, P.D., Zocchetti, C. and Saracci, R. (1987) The International Agency for Research on Cancer Historical Cohort Study of MMMF Production Workers in seven European Countries: Extension of the Follow-up. Annals of Occupational Hygiene, 31, 603-623.

14. Ottery, J., Cherrie, J.W., Dodgson, J. and Harrison, G.E. (1986) A summary report on environmental conditions at 13 European MMMF plants. In: Biological Effects of man-made mineral fibres, Vol 1, pp 83-117. World Health Organisation, Regional Office for Europe, Copenhagen.

15 Dodgson, J., Cherrie, J.WE. and Groat, S. (1987) Estimates of past exposure to respirable man-made mineral fibres in the European MMMF industry. Annals of Occupational Hygiene, 31, 567-582.

16. Enterline, P.E., Marsh, G.M., Henderson, V. and Callahan, C (1987) Mortality update of a cohort of U.S. Man-made Mineral Fibre Workers. Annals of Occupational Hygiene, 31, 625-656.

17. Enterline, P.E., Marsh, G.M., Henderson, V. and Callahan, C. (1987) Mortality among Man-made Mineral Fibre Workers in the United States: mortality update 1978-1982. Final Report to the Thermal Insulation Manufacturers Association. Pittsburgh, University of Pittsburgh Graduate School of Public Health, Department of Biostatistics.

18. Esmen, N.A., Corn, M., Hammond, Y., Whittier, D. and Kotsko, N. (1979) Summary of measurements of employee exposure to airborne dust and fibre in sixteen facilities producing man-made mineral fibres. Journal of the American Industrial Hygiene Association, 40, 118-117.

19 Esmen, N.A. (1984) Short-term survey of airborne fibres in U.S. manufacturing plants. In: Biological Effects of Man-Made Mineral Fibres, Vol.1, pp 65-82. World Health Organisation, Regional Office for Europe, Copenhagen.

20. Shannon, H.S., Jamieson, E., Julian, J.A., Muir, D.C.F. and Walsh, C. (1987) Mortality experience of Ontario Glass Fibre Workers - extended Follow-up. Annals of Occupational Hygiene, 31, 657-662.

21 McDonald, J.C. and McDonald, A.D. (1977) Epidemiology of mesothelioma from estimated incidence. Preventive Medicine, 6, 426-446.

22. Wagner, J.C., Griffiths, D.M. and Munday, D.E. (1987) Experimental studies with palygorskite dusts. British Journal of Industrial Medicine, 44, 749-763.

23. Saracci, R. (1977) Asbestos and lung cancer: an analysis of the epidemiological evidence on the asbestos-smoking interaction. International Journal of Cancer, 20, 323-331.

24. McDonald, J.C. (1984) Peer review: mortality of workers exposed to MMMF-current evidence and future research. In: Guthe, T. (ed.) Biological effects of man-made mineral fibres. Vol, 1. Copenhagen, World Health Organisation, Regional Office for Europe pp 369-380.

25. Rossiter, C.E. and Ellison, J.McK. (1986) Man-made mineral fibres: quantifying hazards. Occupational Health Review, Aug/Sep 1986, 18-21.

Table 1: Production plants included in the European study

Plant	Country	Start of Production	Process	Final follow-up year Mortality	Incidence
1	Denmark	1937	Rock/slag wool	1982	1982
2	Finland	1941	Glass wool	1981	1981
3	Norway	1950	Rock wool	1982	1983
4	Norway	1940	Rock/slag wool	1982	1983
5	Norway	1948	Rock/slag wool	1982	1983
6	Norway	1935	Glass wool	1982	1983
7	Sweden	1933	Glass wool	1982	1982
8	Sweden	1943	Rock/slag wool	1982	1982
9	Sweden	1938	Rock/slag wool	1982	1982
10	U.K.	1943	Glass wool	1983	-
11	U.K.	1946	Cont. filament	1983	-
12	Germany	1941	Rock wool	1982	-
13	Italy	1946	Glass wool	1983	-
		1961	Cont. filament	1983	-

Table 2 Mortality in the European study, including subdivision into those with less than and more than one year of employment

Cause of death	Number of deaths Obs.	Exp.	SMR (95% ci.)	Duration of employment <1yr SMR	>1yr SMR
All causes	2719	2457.0	111* (107-115)	142*	102
All malignant neoplasms	661	597.7	111* (102-119)	115*	109*
Trachea, bronchus, lung	189	151.2	125* (108-114)	113	128*
Respiratory diseases	165	164.9	100 (85-117)	146*	91
Violent deaths	406	264.8	153* (139-169)	227*	117*

* P<0.05

Table 3

European study: Relation between SMR (no. of deaths) and years since first exposure to man-made mineral fibres

Cause of death	Years since first exposure to MMMF 0-9	10-19	20-29	30+
All causes	110* (721)	112* (936)	110* (724)	109 (338)
Cancer of trachea bronchus and lung	96 (39)	112 (70)	104 (51)	152* (29)
Non-malignant respiratory disease	69 (24)	110 (61)	101 (51)	122 (29)

* $P<0.05$

Table 4: European study: Relation between the lung cancer SMR (no. of deaths) and years since first exposure to man-made mineral fibres for the different types of fibre

Type of fibre	Years since first exposure to MMMF 0-9	10-19	20-29	30+
Rock/slag wool	104 (17)	122 (30)	124 (22)	185 (12)
Glass wool	68 (13)	113 (34)	100 (29)	138 (17)
Continuous filament	176 (9)	76 (6)	0 (0)	0 (0)

* P<0.05

Table 5: European study: Relation between the lung cancer SMR (no. of deaths) and years since first exposure for the different technological phases of rock and slag wool production

Technological phase	Years since first exposure 0-9	10-19	20-29	30+
Early	0 (0)	0 (0)	317 (4)	295* (6)
Intermediate	0 (0)	107 (3)	164 (7)	217 (4)
Late	112 (17)	126 (27)	90 (11)	77 (2)

* P<0.05

Table 6: European study: Relation between the lung cancer SMR (no. of deaths), years since first exposure and some possible confounding factors

Technological phase	Years since first exposure 20-29	30+	Total
Use of slag	162 (14)	254* (9)	189* (23)
No slag	87 (8)	102 (3)	91 (11)
Use of bitumen	165 (7)	109 (1)	155 (8)
No bitumen	111 (15)	197 (11)	136 (26)
Use of asbestos	100 (8)	84 (2)	96 (10)
No asbestos	143 (14)	242* (10)	172* (24)

* $P<0.05$

Table 7: Relation between lung cancer incidence and time since first exposure for those in rock/slag wool production

Years since first exposure	Number of cases	Standardized Incidence Rate	95% Confidence Interval
0-9	15	89	50-147
10-19	31	141	96-200
20-29	18	146	87-231
30+	8	158	68-311
Total	72	128	100-161

Table 8: Mortality in the American study (1946-82), and for 1978-82 only. SMRs based on national rates

	1946-82			1978-82	
	Deaths		SMR	Deaths	SMR
Cause of death	Obs.	Exp.	(95% ci)	Obs.	(95% ci)
All causes	4986	4888	102 (99-105)	1251	115** (108-121)
All malignant neoplasms	1052	990	106 (100-113)	322	120** (106-133)
Trachea, bronchus, lung	374	319	117** (105-129)	132	132** (109-154)
Respiratory diseases	232	175	133** (115-150)	69	129 (98-159)
Violent deaths	405	476	85** (77-93)	57	92 (68-115)

* $P<0.05$ ** $P<0.01$

NB Non-malignant respiratory diseases exclude influenza and pneumonia

Table 9:

American study: Relation between the respiratory cancer SMR (no. of deaths) and years since first exposure to man-made mineral fibres for the different types of fibre. SMRs based on local rates.

Type of fibre	Years since first exposure to MMMF 0-9	10-19	20-29	30+
Mineral wool	90 (2)	157 (13)	127 (20)	135 (25)
Glass wool	95 (5)	107 (22)	104 (39)	137 (13)
Continuous filament	104 (6)	53 (9)	119 (36)	80 (13)
Both glass wool and cont. filament	90 (6)	110 (27)	112 (66)	110 (89)
Ever exposed to fine glass fibres	61 (1)	128 (7)	105 (8)	198 (6)

* $P<0.05$

Table 10:

American study: Relation between the non-malignant respiratory disease SMR (no. of deaths) and years since first exposure to man-made mineral fibres for the different types of fibre. SMRs based on local rates.

	Years since first exposure to MMMF			
Type of fibre	0-9	10-19	20-29	30+
Mineral wool	0 (0)	230 (7)	148 (11)	124 (14)
Glass wool	94 (1)	86 (8)	125 (23)	141 (8)
Continuous filament	0 (0)	124 (10)	104 (17)	69 (7)
Both glass wool and cont. filament	0 (0)	97 (12)	118 (46)	89 (48)
Ever exposed to fine glass fibres	0 (0)	44 (1)	164 (6)	113 (2)

NB Non-malignant respiratory diseases exclude influenza and pneumonia

Table 11: Mortality in the Canadian study overall and for those who had worked in the production plant only

Cause of death	All deaths Obs.	All deaths Exp.	SMR (95% ci.)	Plant only deaths Obs.	Plant only deaths Exp.	SMR (95% ci.)
All causes	157	187.5	84* (71-97)	137	152.9	90 (75-105)
All malignant neoplasms	42	39.3	107 (77-145)	37	31.6	117 (82-161)
Trachea, bronchus, lung	21	11.9	176* (109-270)	19	9.5	199* (120-311)
Respiratory diseases	4	8.9	45 (12-115)	4	7.3	55 (15-140)
Violent deaths	27	40.1	67* (44-98)	25	33.8	74 (48-109)

* $P<0.05$

Table 12: Canadian study: Relation between lung cancer mortality and time since first exposure

Years since first exposure	Number of cases	Standardized Mortality Rate	95% Confidence Interval
0-9	2	244	29-881
10-19	5	198	64-462
20-29	7	162	65-334
30+	5	270	87-630
Total	72	128	98-158

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A MODERN FUEL FROM AN AGE OLD PROCESS - LANDFILL GAS

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1 Introduction and History

Nine years have elapsed since the first experiments (1) to harness landfill gas as a fuel were carried out at Stewartby, in Bedfordshire. These studies, which were a combined London Brick Landfill, Harwell and Department of Energy venture, rapidly advanced the UK's knowledge base, establishing that landfill gas existed in quantity and could be used as a fuel.

By 1983 the first large scale boiler conversion to take landfill gas had been made at a paper mill (2) in Purfleet, Essex and the scene was set for the greater exploitation of landfill gas in the UK. Landfill gas had ceased to be a mere scientific curiosity, it had become a credible source of renewable energy (3). In the following three years further schemes were embarked upon, several with Department of Energy assistance through the Energy Efficiency Demonstration Projects Scheme.

All was going well, then came the dramatic fall in energy prices in 1986 which took place as a direct result of the oil price collapse. This fall should have resulted in a slowing down in the pace of the industry's expansion. However, such a slow-down was not seen in the UK, indeed the contrary was true, the industry continued to expand ever more rapidly. The reason for this remarkable state of affairs was the rise in the importance of environmental control of landfill gas.

Gas exploitation for energy has long been promoted as 'good housekeeping' along with other good waste management practices. By extracting the gas and putting it to beneficial use as a fuel it is prevented from entering the environment in an uncontrolled manner. As a result of various incidents with uncontrolled landfill gas emissions (discussed later), the good sense in gas control for both energy and environmental

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The views expressed in this paper are those of the author and do not necessarily represent those of ETSU, the UKAEA or the Department of Energy.

need was at last realised. Many companies have since embarked on exploitation schemes where energy recovery alone would not have been a sufficient driving force. Strong underpinning from environmental need, effectively giving an 'environmental credit' to a project has thus taken place.

2 Landfill Gas Exploitation - the Current Picture

There now exist in the UK 24 utilisation schemes drawing landfill gas from 18 different landfill sites (See Table 1 - Landfill Gas Commercial Projects). Currently, 8 projects are under construction whilst a further 18 schemes are known to be at the (serious) planning stage. By the end of this year energy savings worth an estimated £8m will be made through the use of landfill gas, rising to double this figure in 1989/90. Such a picture makes the United Kingdom second (4) only to the United States in the 'International League' of fifteen landfill gas exploiting nations.

Figure 1 plots the likely dramatic rise in energy savings over the period from 1986 to 1989, landfill gas being used in a variety of different ways, in kilns, boilers, and for power generation. The shift to power generation is particularly noticeable over the period, reaching nearly 50% of all landfill gas exploited by 1989 - seen clearly in Figure 2 (Landfill Gas Utilisation Pie Chart).

Further growth of gas exploitation into the 1990s and beyond is to be expected but the rate of that growth and the split in the pattern of consumption is harder to predict. In order to produce anything like a calculated guess of where the industry might go, consideration must be given to a number of constraints on the industry.

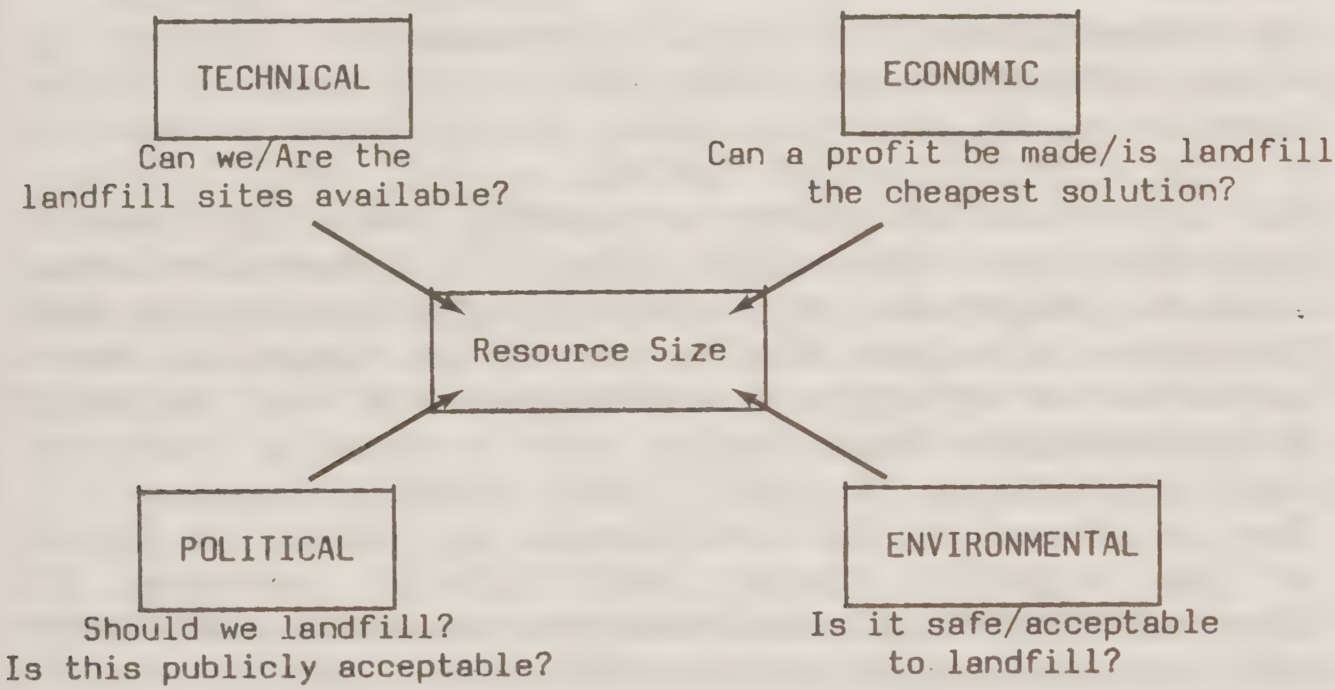
These are:

- o technical constraints
- o economic constraints
- o environmental issues and constraints
- o political issues and constraints
- o developments in the waste industry structure.

Technical Constraints

Perhaps the largest and most fundamental constraint is that of resource size. Since landfill gas is obtained from landfilled waste, an increase or decease in the amount of waste infilled or a variation in the method of filling will have an immediate impact on the 'potential' gas resource.

A need or desire to change the route of waste disposal can arise from a number of different directions. The major issues are:



Currently some 90% of an estimated 40 million tonnes of UK refuse is landfilled (20m tonnes household and 20m tonnes industrial/commercial, excluding 'inert' construction and demolition wastes). Any future variation in the figure is likely to be downward, bearing in mind the high proportion of waste currently landfilled. However, two factors are likely to moderate any impact on landfill and landfill gas. Firstly, the reduction will be slow since other disposal options (5) are either much more expensive or at an early stage in their development. Secondly, most landfill gas is produced between years 2 and 15 after filling. Hence, even a major change away from landfilling in the next 5 years will have limited impact on gas availability until well after the turn of the century.

Much more important are changes in waste composition and/or the method of filling since these will also affect gas production. For example the following might be expected:

More gas produced	Less gas produced
Fewer but larger sites	More smaller sites
Increase in Organic Content	Decrease in Organic Content
Decrease in Toxic Waste	Increase in Toxic Waste
Increase in Active Biomass (eg Sewage Sludge)	—
Optimum Conditions for Digestion	Inhibition of Digestion Process

The Department of Energy is currently evaluating numerous methods of gas optimisation under the Renewable Energy (Biofuels) Programme (6). Current projections indicate that the economic resource size for landfill gas abstraction might be doubled or trebled to 3 million tonnes of coal equivalent in the forseeable future.

The Department of the Environment, by contrast, is looking at gas migration control and inhibition processes (7). Together, these two co-ordinated programmes should develop safe, environmentally sound methods of exploiting landfill gas.

A further technical constraint on the industry is that of the efficiency of gas abstraction technology itself. Best estimates are that only 75% of gas produced in a site can be extracted and used. A combination of better well design and waste management might be expected to increase this figure substantially. Again, the Department of Energy (6) is evaluating better equipment and design.

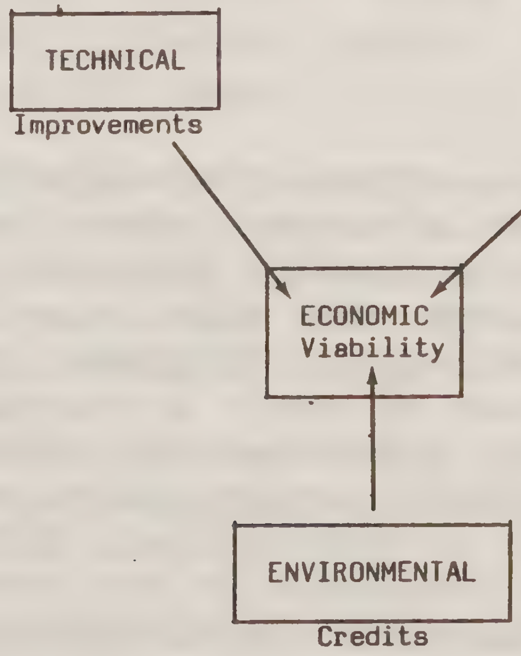
Economic Constraints

Landfill gas will be successfully exploited only if it is competitively priced against other competing sources of energy. Further, the industry is producer led and gas will only be exploited if the producer can make a profit.

Historically, it has been the quarrying industry, uniquely placed as producer and potential user, which has nurtured landfill gas exploitation for energy. This industry has seized the opportunity of using locally produced low cost gas as a replacement fuel in kilns. A highly attractive option and one likely to remain so for the forseeable future. Other local highly energy intensive industries have also been able to obtain gas from producers via a dedicated pipeline, often at a price 10-20% lower than than paid for their usual fuel (eg gas, oil or coal). Such opportunities for selling gas are fewer in number however, and depend on lucky geography.

Increasingly, operators have turned to power generation and export of electricity to third parties or the national grid, as a means of exploiting gas, particularly from the more remote and rural sites. Such a strategy ensures maximum producer control and should reduce the complications of negotiating end-user contracts. However, in revenue terms, generation and sale of electricity is likely to be a less lucrative option than the supply of gas to a local user via a dedicated pipeline, even at today's low energy prices. Further discussion is made of user options in an earlier paper (8). The range of industries using landfill gas is shown in Figure 3.

Apart from the direct costs and benefits which make up the the economic case for a landfill gas scheme there are three additional concerns or inputs:



Improvements in gas yield and annual production rate offer the opportunity of increased revenue from schemes bettering the economic case. Political (UK or EEC) factors may work against a project; for example, onerous regulations and safeguards may require considerable additional expenditure to be made, worsening the economic prospect. In the reverse direction financial assistance might be available which will boost a project's attractiveness.

The Energy Efficiency Demonstration Projects Scheme (EEDS)

The Department of Energy through the EEDS has sponsored a series of nine producer and user projects to demonstrate the technical and commercial viability of using landfill gas as a fuel. All schemes have to date proven successful and have provided a technical lead to the industry. A list of these projects is given in Table 2 along with their respective Project Profiles (see Appendix 1). Further detailed project information is available from other sources (9–12).

The EEDS has had significant impact on the growth of the landfill gas industry advancing the technology by as much as five years. Grants of up to 25% offered towards project installation and capital cost have enabled schemes to progress when still viewed as both technically and economically risky. Dr Currie of ETSU has recently reviewed (13) the achievements of the scheme after 10 years of operation.

Environmental

The production of landfill gas occurs quite naturally through the anaerobic decomposition of organic matter in landfills. The organisms responsible are some of the oldest known on our planet having evolved some 3500 million years ago when our atmosphere itself was anaerobic (depleted in oxygen). See Figure 4. The process of decay is complicated but remarkably resilient since anaerobes find conditions in modern day landfills very much to their liking - hence they thrive.

Left uncontrolled the evolution of landfill gas presents an

environmental problem due to both malodour and danger through either the potentially asphyxiating or explosive nature of the gases.

Recent reports in the press testify to an increasing hostility of the public towards landfilling, partly as a consequence of landfill gas mismanagement, or no management at all! The most celebrated case is of an incident at Loscoe in Derbyshire (14) where inadequate provision resulted in a serious escape of gas to nearby housing.

The Department of the Environment has set about tightening the control of landfill gas in recent months, two waste management papers being relevant (15). All in all it is quite clear that landfill gas can no longer be left uncontrolled. Waste Management paper 27 (draft) states: 'Gas should not be allowed to migrate in an unplanned or uncontrolled manner from a landfill, but should be controlled by a properly designed gas management system. No site should be licensed without such a system forming part of the working plan'.

The 'management system' may not necessarily be a pumped one, although for larger sites this would seem only prudent. However, where such a system was employed, gas being abstracted and flared, then the beginnings of an exploitation scheme are laid. Expansion of a control scheme to incorporate maximum gas exploitation for energy if planned and executed properly should greatly enhance the environmental protection aspects. This point is accepted in Waste Management paper 27.

Clearly, environmental protection must remain a priority and any combined energy and control scheme must be 'fail-safe'. Hence, the control system must be able to function independently and cope with any extra load that might be placed upon it should the commercial system not be needed.

In terms of the economics of a project the incorporation of an environmental control element effectively gives an 'environmental credit' towards an energy exploitation project. Such a credit can be substantial and make the difference between an economic or non-economic scheme.

Environmental concerns do not remain at the 'micro' scale, there are 'macro' impacts too. Landfill gas is a 'cocktail' of gases mostly composed of methane, carbon dioxide, nitrogen, oxygen and hydrogen. In addition there are traces of numerous other gases including organosulphur and halogenated compounds. (Many CFCs or chlorofluorocarbons).

Virtually all of these gases are classic 'greenhouse gases', that is they contribute to the warming up of our planet. Further, CFCs are believed to lead to attack of the earth's 'ozone layer'. Figure 5 shows the contribution made by different gases to the greenhouse effect. Figure 6 the growth in gases and their 'radiative forcing' (16). Carbon dioxide is the major culprit but other gases such as CFCs are growing in their relative importance.

Once produced, landfill gas left uncontrolled will leak out into the atmosphere adding to the greenhouse effect - perhaps not a great deal in global terms, but nevertheless to a significant degree. If, however, landfill gas is burnt then two important gases are destroyed - methane and CFCs. Methane itself admittedly forms carbon dioxide, itself a contributor.

However, since the 'radiative forcing' of methane is much greater than that of carbon dioxide, overall the effect is a beneficial one. In addition CFCs are destroyed although NO_x and SO_x will be created.

Currently emissions from several landfill gas projects are being monitored and the results will be available in 1989 allowing for a better appreciation of the macro as well as the micro environmental impact of landfill gas and its utilisation. Such work may prove timely as the CEC is becoming increasingly interested in emission standards for waste as well as fuel projects.

Political

Apart from the obvious beneficial impact of the Department of Energy's sponsorship of individual projects on landfill gas, the 1983 Energy Act has also made its mark. This Act has enabled private generators of electricity to export to the

national grid setting the scene for the growth in power generation from landfill gas. Further developments including the privatisation of the electricity industry in the near future may make power generation an even more attractive option.

A general tightening up of management activities of sites is occurring as a result of increasingly tight restrictions placed upon operators by the Department of the Environment. This trend is likely to continue and if anything be added to by future CEC initiatives.

Developments in the Waste Industry Structure

The total value of the British waste (non-hazardous industrial, domestic and commercial solid waste) market is thought to be around £530m per annum, of which the private sector share is around 75% (around £400m). More money is involved in waste collection than in waste disposal, the latter accounting for perhaps £180m per annum, of which £115m is in the private sector. As service industries go, this is relatively small beer. However, the industry continues to attract large company interest.

In the past few years there have been dramatic changes in the makeup of the waste industry, particularly in the private sector. A rapid process of rationalisation and consolidation appears to be taking place, mainly through acquisition. Fewer, but larger companies are emerging who are:

- increasing the effective operating range of their individual depots
- operating regionally by organising their collection locations in such a way as to allow fleet coverage
- fiercely competitive.

Examples of companies exhibiting this trend are Cleanaway, with the largest turnover in the UK and Shanks and McEwan. Table 3 lists the principal private waste management companies, their sales revenue and a description of their operations.

Rationalisation is likely to lead to pressure for fewer but larger landfill operations. In general, I would view this as a positive development on both energy as well as environmental grounds since:

- o Larger sites intrinsically are likely to provide higher yields of gas. Additionally, gas enhancement and gas utilisation will benefit from the larger scale of operation, maximising any economies of scale.

- o Fewer, larger sites should be easier to police, hence better standards should be adopted as a rule.

- o Fewer companies with more capital invested will 'raise the stakes' in the industry increasing company sensitivity to adverse publicity (eg through less than thorough site management).

3 Landfill Gas Exploitation - Where to now?

In the previous section of this paper the many and various pieces of the complex jigsaw that is landfill gas exploitation today have been assembled.

Pulling the pieces together gives the following picture:

- o The industry is alive, well and growing rapidly.

- o Early exploitation has been guided by energy needs and was nurtured by the quarrying industry - uniquely positioned as both gas producers and user.

- o Following the relaxation of regulations regarding private generation and export to the grid, the more remote sites have initiated power generation schemes.

- o More recently, heightened concern about the environmental impact of uncontrolled landfill gas emissions has led to a tightening up of gas management at sites. This environmental concern has more than counterbalanced the loss of interest in exploitation for energy following the 1986 energy price crash.

Based upon the existing evidence, plans afoot and a degree of speculation I would say that the industry in the UK will:

- o Continue to grow driven by both an energy as well as an environmental need to control gas.
- o Be saving energy worth some £65m (1 million tonnes of coal equivalent) by the late 1990s. See Figure 7 - landfill gas market penetration.
- o Be using, some 60 - 65% of all gas exploited for power generation by the late 1990s.
- o Be incorporating much higher standards of waste management resulting in still higher gas production rates, doubling the technical potential to 2 Mtcepa during the 1990s.
- o Be an industry with fewer, but larger players with more at stake in controlling and using their landfill gas. (In today's money, the revenue gained from gas exploitation will be some £65m per annum, by the late 1990s, or 12% of the industry's total revenue.)

4 Municipal Solid Waste and Leachate Digestion

There is a limit to that which might be achieved in the energy and environmental management of wastes placed in landfills. Progressively more control must be exerted over the process of decomposition and this will necessitate the adoption of increasingly sophisticated bioreactors. To begin with these may be lined 'holes in the ground' allowing for the recirculation of liquids with the opportunity for nutrient addition to boost biodegradation performance. However, eventually the move must be made to fabricated systems incorporating enhanced materials recovery and perhaps an element of waste combustion technology. The effect on the recoverable energy potential is dramatic (see Figure 8) reaching perhaps 5 million tonnes of coal equivalent per annum. Of course, such options are currently in the early stages of development and the likely cost case will only make them economic in some circumstances. Nevertheless,

their future should be considered seriously by the waste industry and the predominantly biologically based processes allowed to develop naturally alongside existing landfill industry operations.

In view of the considerable energy potential, but high risks of adopting enhanced waste treatment and recovery techniques, the Department of Energy through the Renewable Energy Programme (Biofuels), is currently reviewing the various technologies to assess their potential. Two paper studies have been initiated to date, one on liquid digestion, the other on solid waste digestion.

Liquid Digestion

A study has been commissioned on behalf of the Department of Energy to examine the opportunities for energy recovery from existing landfill derived liquids, or leachates, in the UK. The work is being carried out by the Water Research Centre (WRC) at Medmenham and an interim report (17) is available.

Essentially, it is already known that certain methods of anaerobically treating leachates are very successful, leading to the rapid destruction of polluting materials whilst also yielding a good quality biogas. Little however, is known of the existing landfill leachate 'resource' and hence the WRC have been directed to map this potential. The paper study will allow the benefits of leachate digestion at existing sites to be investigated. In addition, WRC will make a first assessment of ther feasibility of adopting liquid recirculation techniques in landfill, a move towards the so-called 'biofill' concept (see Figure 9) linked to external digestion in a fabricated reactor.

Municipal Solid Waste (MSW) Digestion

The second study has been carried out by Drs J and Y Coombs of the British Anaerobic and Biomass Association (BABA). Once more an interim report (18) is available.

The purpose of the study is to evaluate the present state of knowledge concerning the Anaerobic Digestion of the organic

fraction of MSW in fabricated digesters with the aim of recovering energy in the form of gas, heat and power.

The report contains a comprehensive global review and appraisal of all relevant digestion studies including Valorga (France), Dranco (Belgium) EPCOT and Refcom (USA). Three types of processes have been identified:

- o Conventional Stirred Reactors (Low solids of less than 10%)

- o Plug flow type Reactors (Much higher solids)

- o Multi-stage reactors (including 'leached bed' systems).

The first two types of systems have mainly treated the putrescibles or fines fraction of MSW. The multi-stage reactor appears more pertinent to whole MSW digestion.

The study is yet to be completed but interim results indicate the following:

- o That the energy which could be recovered through digesting MSW in fabricated digesters is potentially much greater than from conventional landfilling.

- o That control of the digestion (and hence gas producing) process is much greater in fabricated systems leading to beneficial environmental spin-off.

- o That the cost of treating MSW digestion by using fabricated digesters would be high in comparison to conventional landfilling. Indeed it is unlikely to be less than £10/tonne and the process will initially only compete where landfilling and/or tranport costs are high (See Figure 10 - MSW disposal costs).

The report suggests that the additional cost of treating waste using digesters might well be justified in the light of increasing environmental concerns and that a case exists for further investigation - perhaps field trials of promising technology in the near future. With considerable industrial interest in the technology both at home and abroad such a

suggestion appears reasonable. Dr Coombs also points out that, for the UK at least where MSW has a relatively low putrescible content (see Figure 11), sorting at source should be considered to boost the organic fraction. Such a strategy would allow gas production to be maximised and present the best economic situation.

There are extensive implications for waste collection as well as waste disposal in sorting at source. Historically, such moves have been less than enthusiastically received by both the public as well as the waste disposal industry. Perhaps in the light of the public's increasing awareness and concern over waste disposal a second look is merited.

References

1 Moss H. D. T. and Manley B. J. W. 1986. Review of Landfill Gas Field Projects. Energy from Landfill Gas Conference, Solihull.

2 Final Project Report 1985. The Use of Landfill Gas as a Replacement Fuel in a Water Tube Boiler. ED/60/153.

3 Richards K. M. 1984. Anaerobic Digestion. A Credible Source of Energy. Proceedings of the Fourth International Conference of Electrical Engineers, London.

4 Richards K. M. 1987. Landfill Gas - A Global Review. Proceedings of the Seventh International Biodeterioration Symposium, Cambridge. ETSU-L-22.

5 Brown, A. 1988. Refuse - The Energy Options. Proceedings of the Landfill Gas and Anaerobic Digestion of Solid Wastes Conference, Chester.

6 Lawson P. S. 1988. The UK Department of Energy Landfill Gas Research and Development Programme. Proceedings of the Landfill Gas and Anaerobic Digestion of Solid Wastes Conference, Chester.

7 Gronow J. 1988. The Department of the Environment Landfill Gas Research and Development Programme. Proceedings of the Landfill Gas and Anaerobic Digestion of Solid Wastes Conference, Chester.

8 Richards K. M. 1987. Landfill Gas - The Sweet Smell of Success. Proceedings of the IEE Energy Options Conference, Reading.

9 Moss H. D. T. 1988. Electricity Generation Using Landfill Gas Fuelled Spark Ignition Engines. Proceedings of the Landfill Gas and Anaerobic Digestion of Solid Wastes Conference, Chester.

10 Pike D. C. and Limbrick A. J. 1988. Electricity Generation from Landfill Gas at Waspey's Wood, Buckinghamshire, Using Duel Fuel Engines. Proceedings of the Landfill Gas and Anaerobic Digestion of Solid Wastes Conference, Chester.

11 Biddle C. A. R. Power Generation Using Gas Turbines Fuelled by Landfill Gas. Proceedings of the Landfill Gas and Anaerobic Digestion of Solid Wastes Conference, Chester.

12 Adamson A. 1988. The Mucking Landfill Gas Direct User Scheme. Proceedings of the Landfill Gas and Anaerobic Digestion of Solid Wastes Conference, Chester.

13 Currie W. M. 1988. Chasing the Energy Efficiency Goal. Atom, 22, 8-12.

14 Report of the Non-Statutory Public Enquiry into the Gas Explosion, Derbyshire, 24 March 1986. Available from Derbyshire County Council.

15 Waste Management Papers 26 and 27. Available from Department of the Environment.

16 Wigley T. M. L. 1987. Relative Contribution of different trace gases to the greenhouse effect. Climate Monitor 16, 14-18.

17 Young C. P., Mosey F. E. and Maris P. J. 1988. Leachate Digestion in the UK. Proceedings of the Landfill Gas and Anaerobic Digestion of Solid Wastes Conference, Chester.

18 Coombs J. and Coombs Y. R. 1988. The Potential for Recovery of Energy from Solid Wastes in the UK Using Anaerobic Digeston in Fabricated Reactors. Proceedings of the Landfill Gas and Anaerobic Digestion of Solid Wastes Conference, Chester.

Figure 1

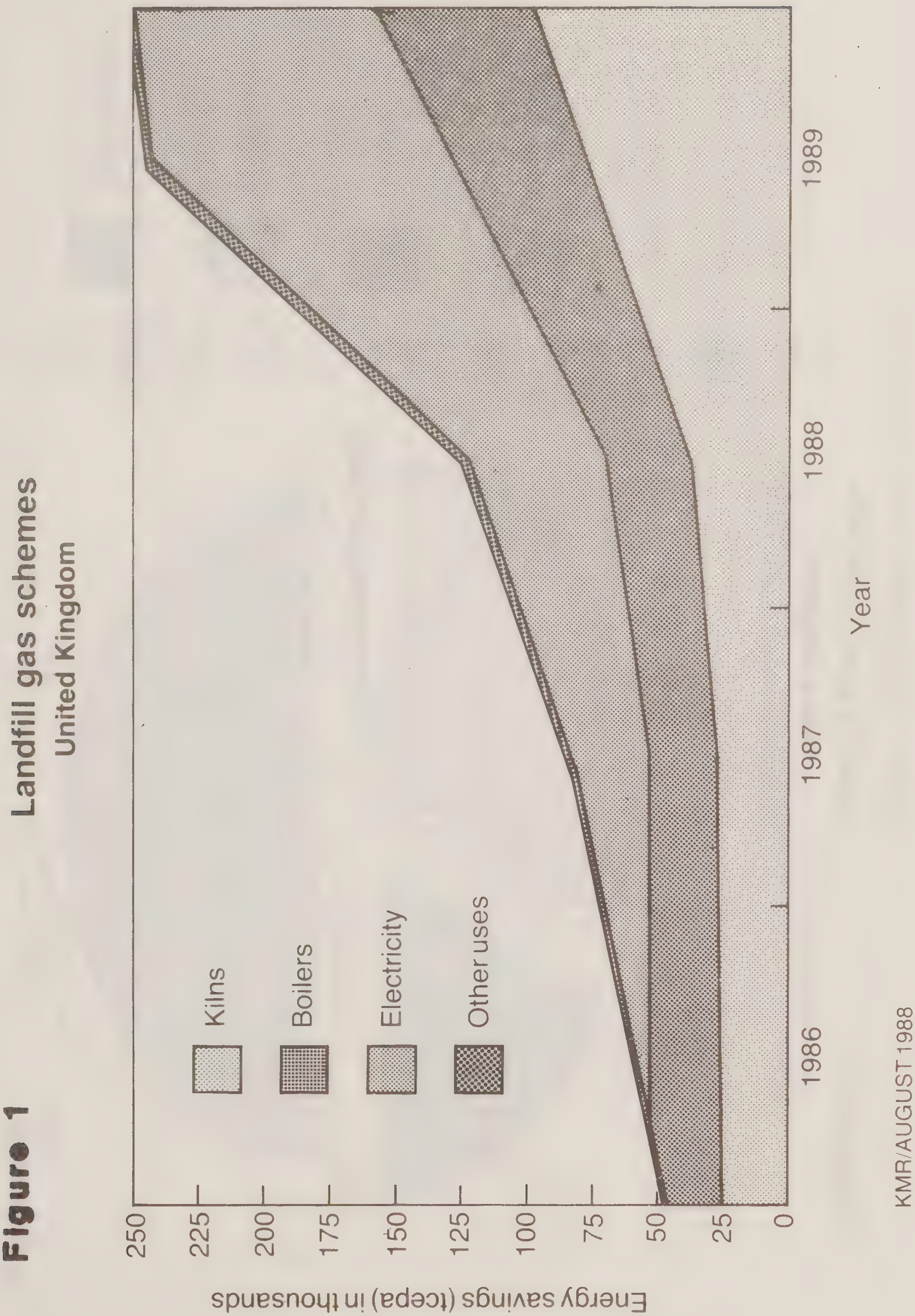

Landfill gas schemes
United Kingdom
Energy savings (tcepa) in thousands
250
225
200
175
150
125
100
75
50
25
0
1986
1987
1988
1989
Year
Kilns
Boilers
Electricity
Other uses
KMR/AUGUST 1988

Figure 2

Landfill gas schemes
United Kingdom
Anticipated energy use 1989

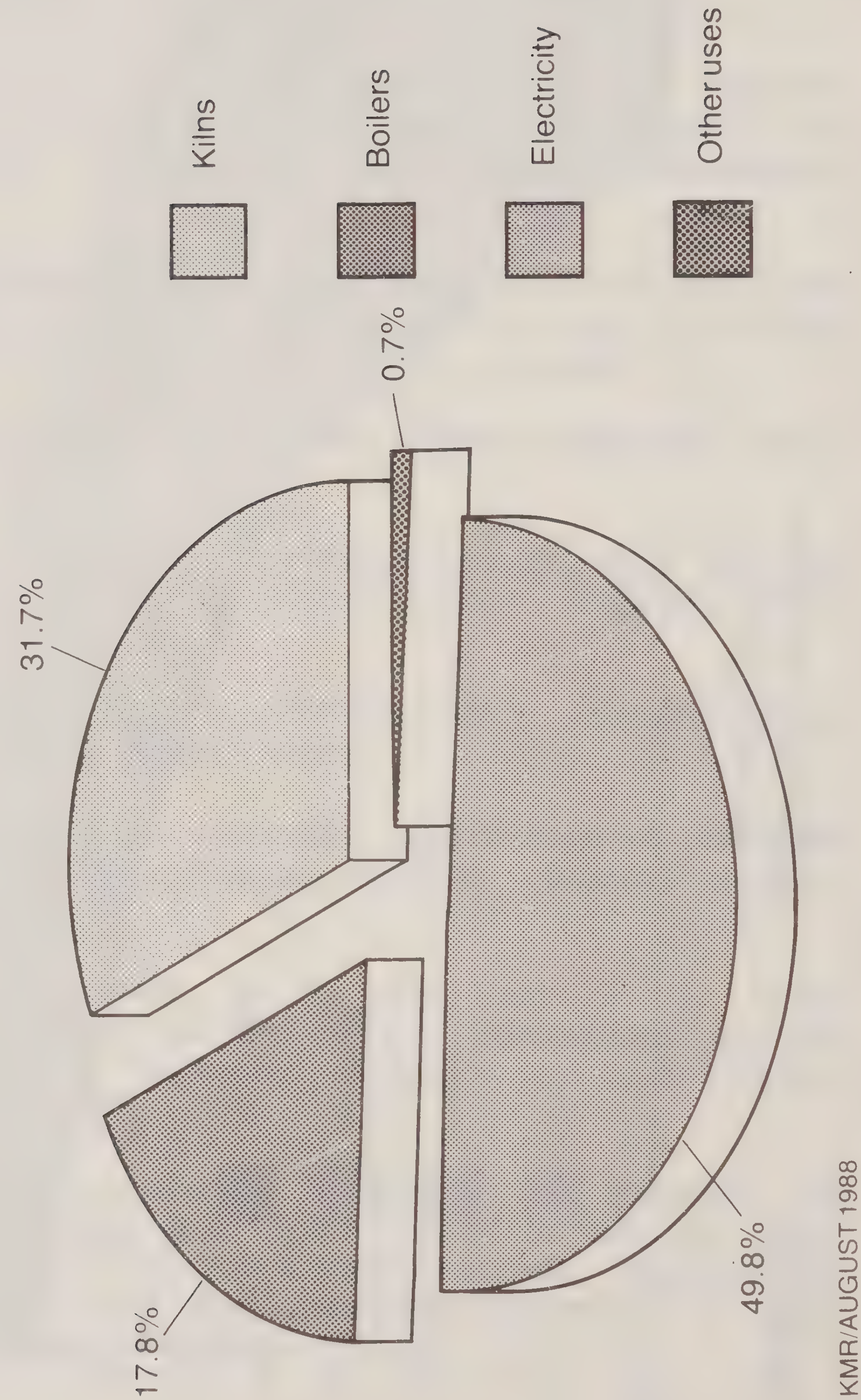
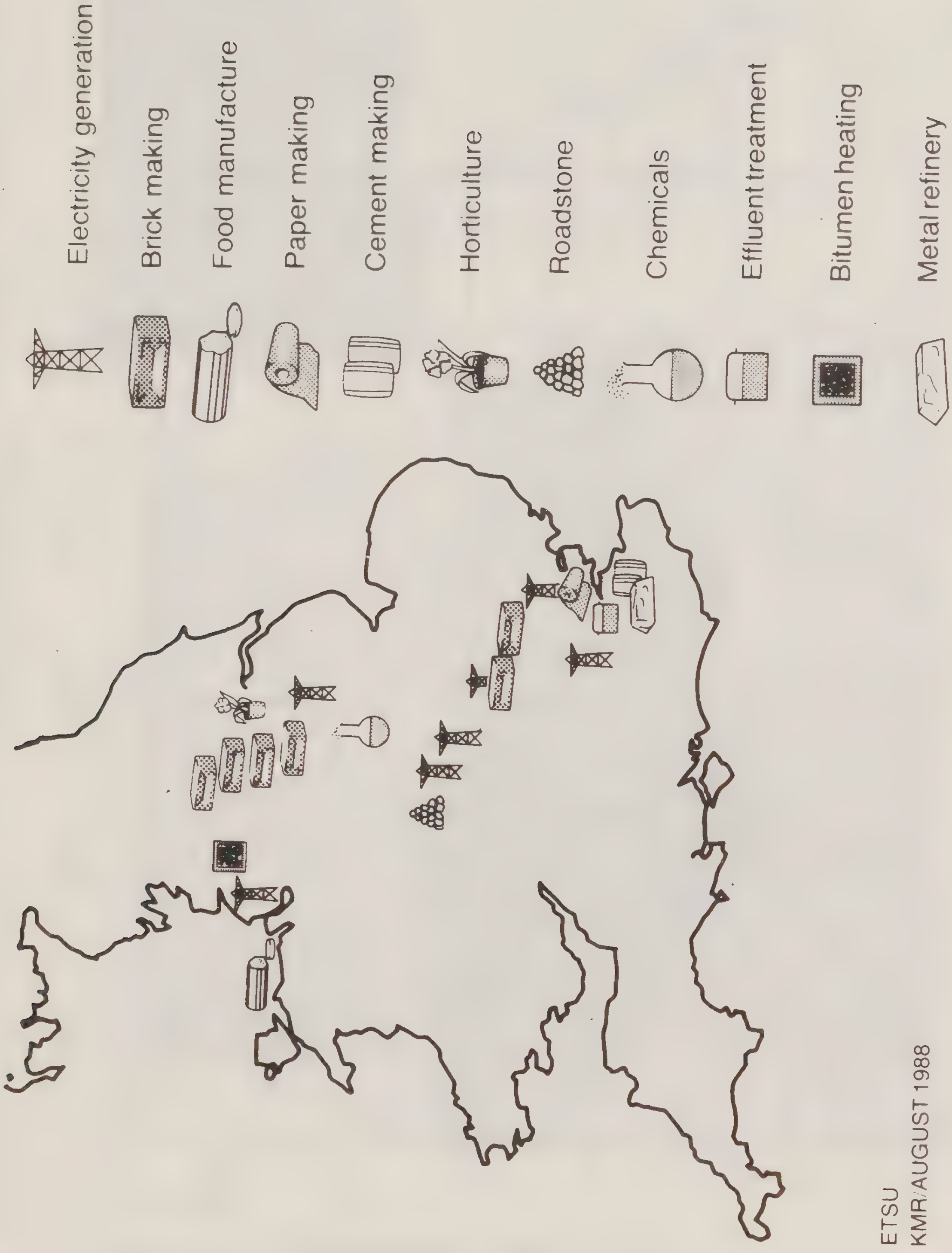


Figure 3



Current use of landfill gas by industry

Figure 4

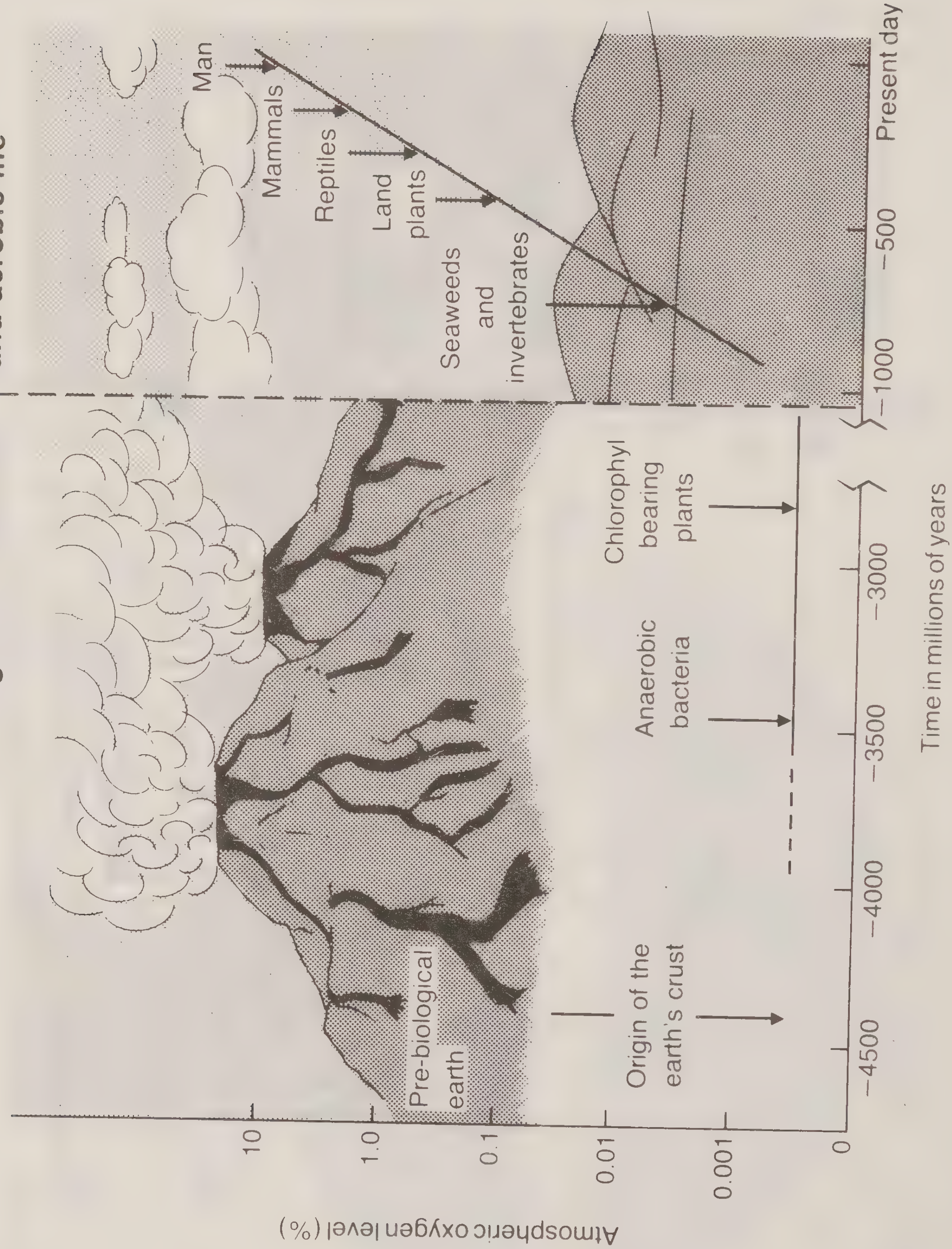
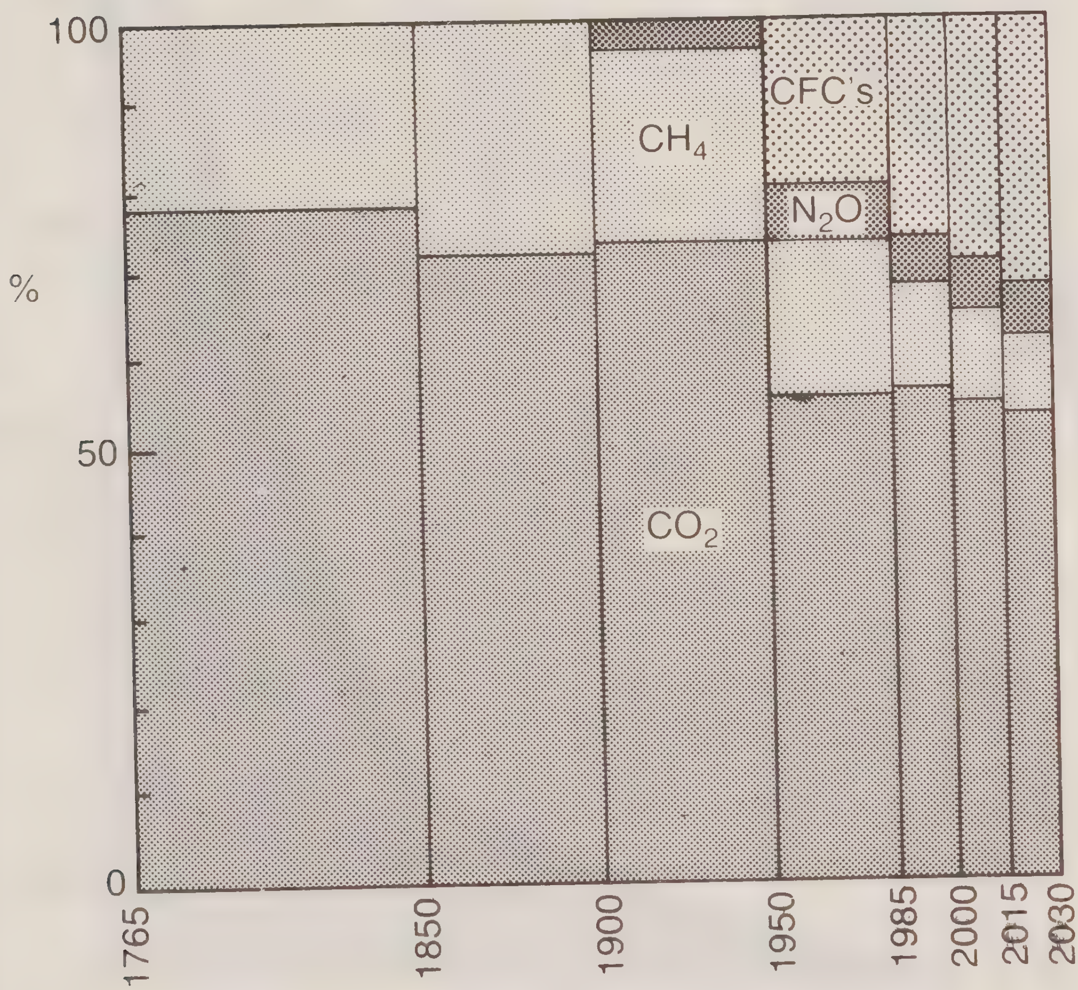

The origins of anaerobic and aerobic life
Atmospheric oxygen level (%)
10
1.0
0.1
0.01
0.001
0
Pre-biological earth
Origin of the earth's crust
Anaerobic bacteria
Chlorophyl bearing plants
Seaweeds and invertebrates
Land plants
Reptiles
Mammals
Man
−4500
−4000
−3500
−3000
−1000
−500
Present day
Time in millions of years

Figure 5

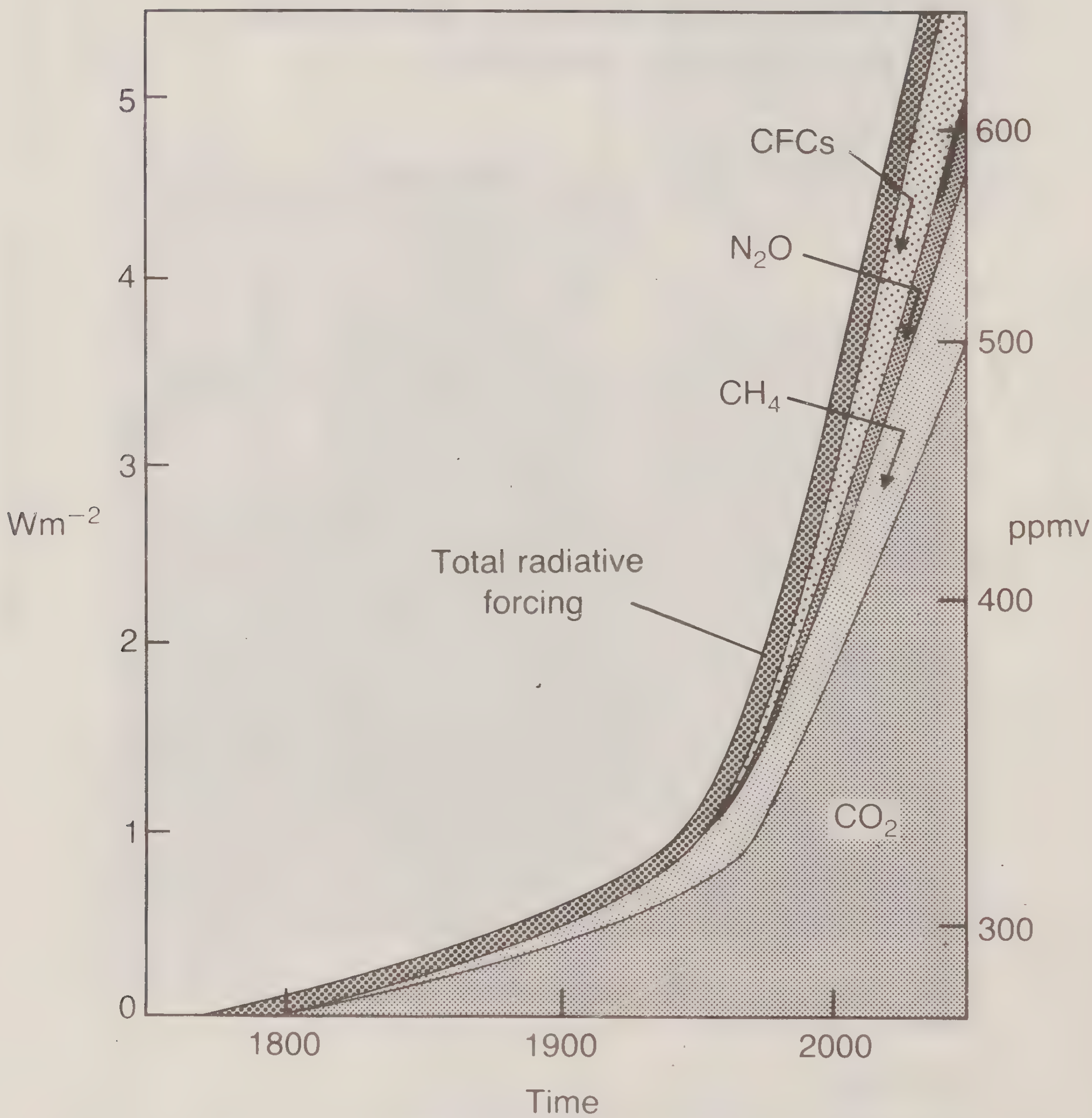
"Greenhouse Gases" – percentage contributions over time



T.M.L. Wigley
Climate Monitor 1987

Figure 6

Growth in 'Greenhouse' gases



T.M.L. Wigley
Climate Monitor 1987

Figure 7 Landfill gas. Market penetration/anticipated energy contribution

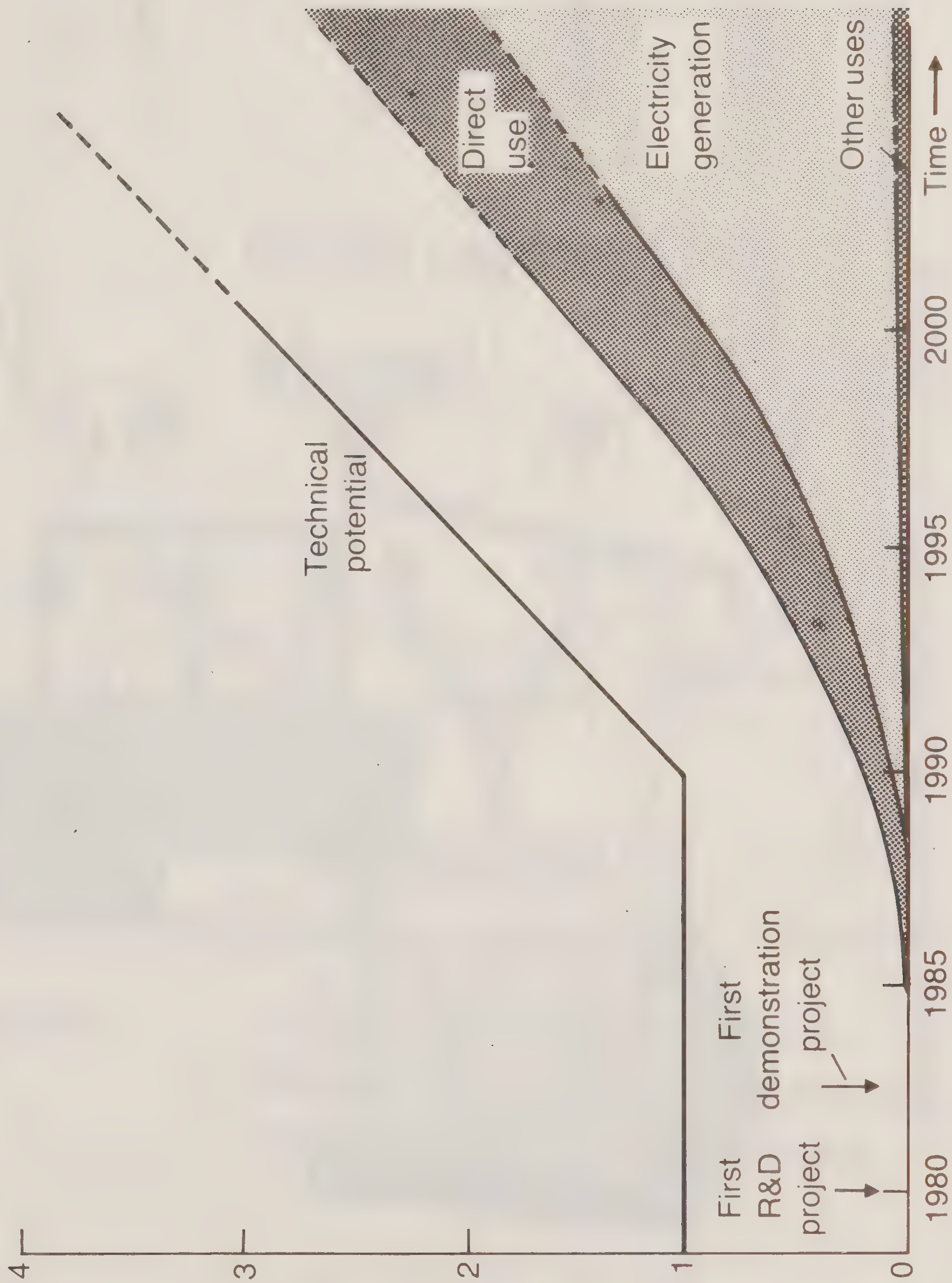


Figure 8 REFUSE – Biological Processing Energy Options

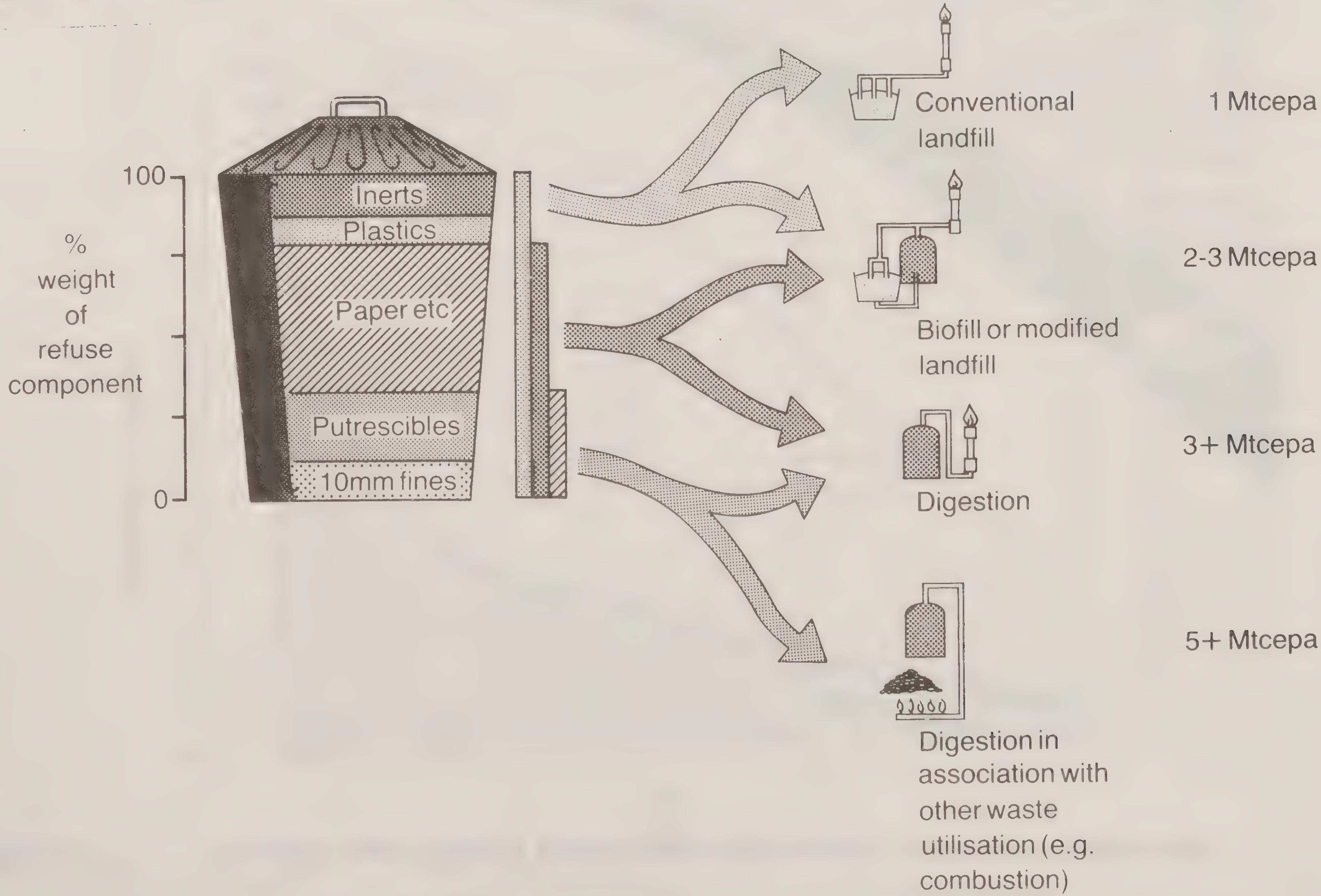
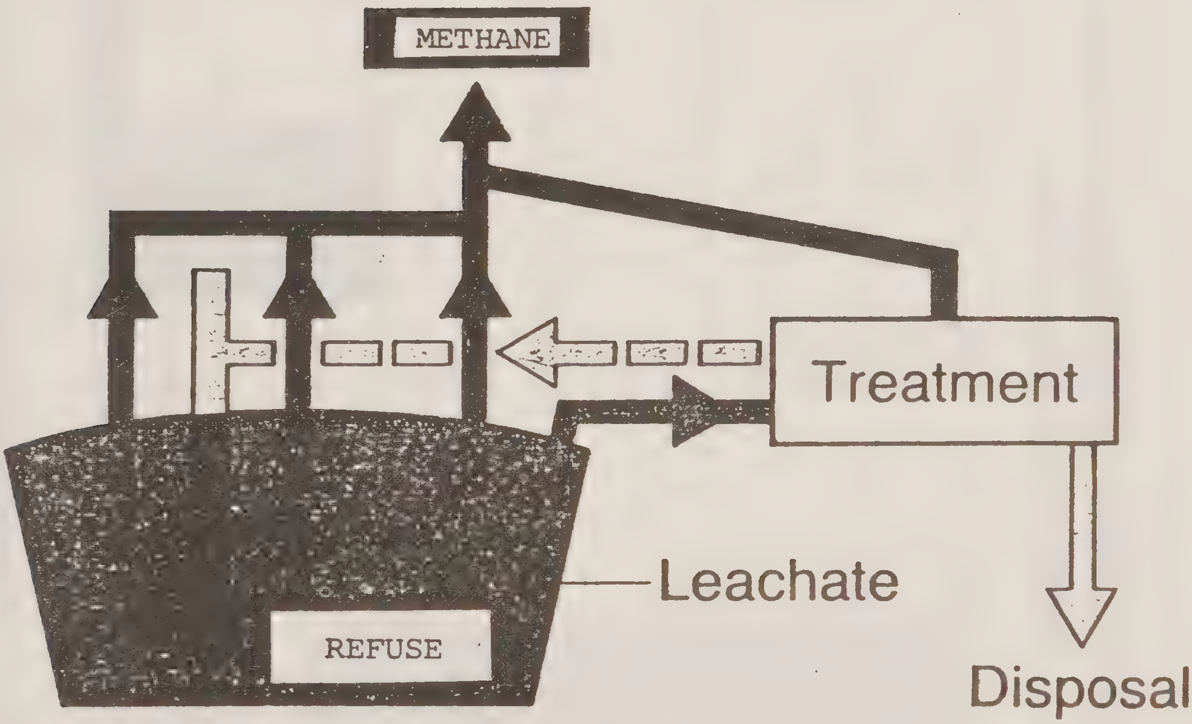


Figure 9

Biofill concept



Control

Landfill geometry and siting
Refuse input (type and method)
Water/leachate management

Figure 10

Municipal solid waste disposal costs
England and Wales (CIPFA)

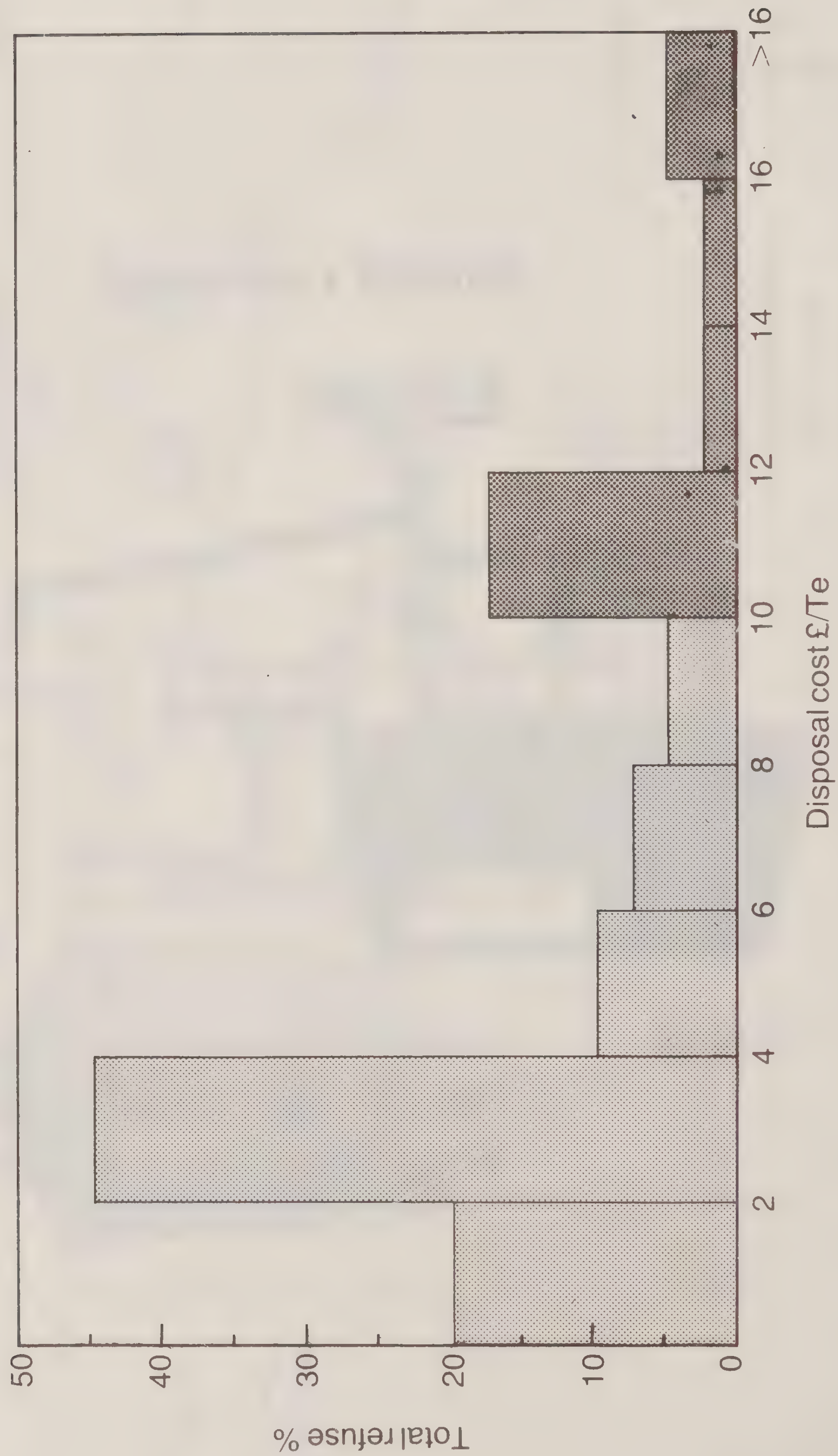


Figure 11

Effect of sorting on energy potential of raw waste

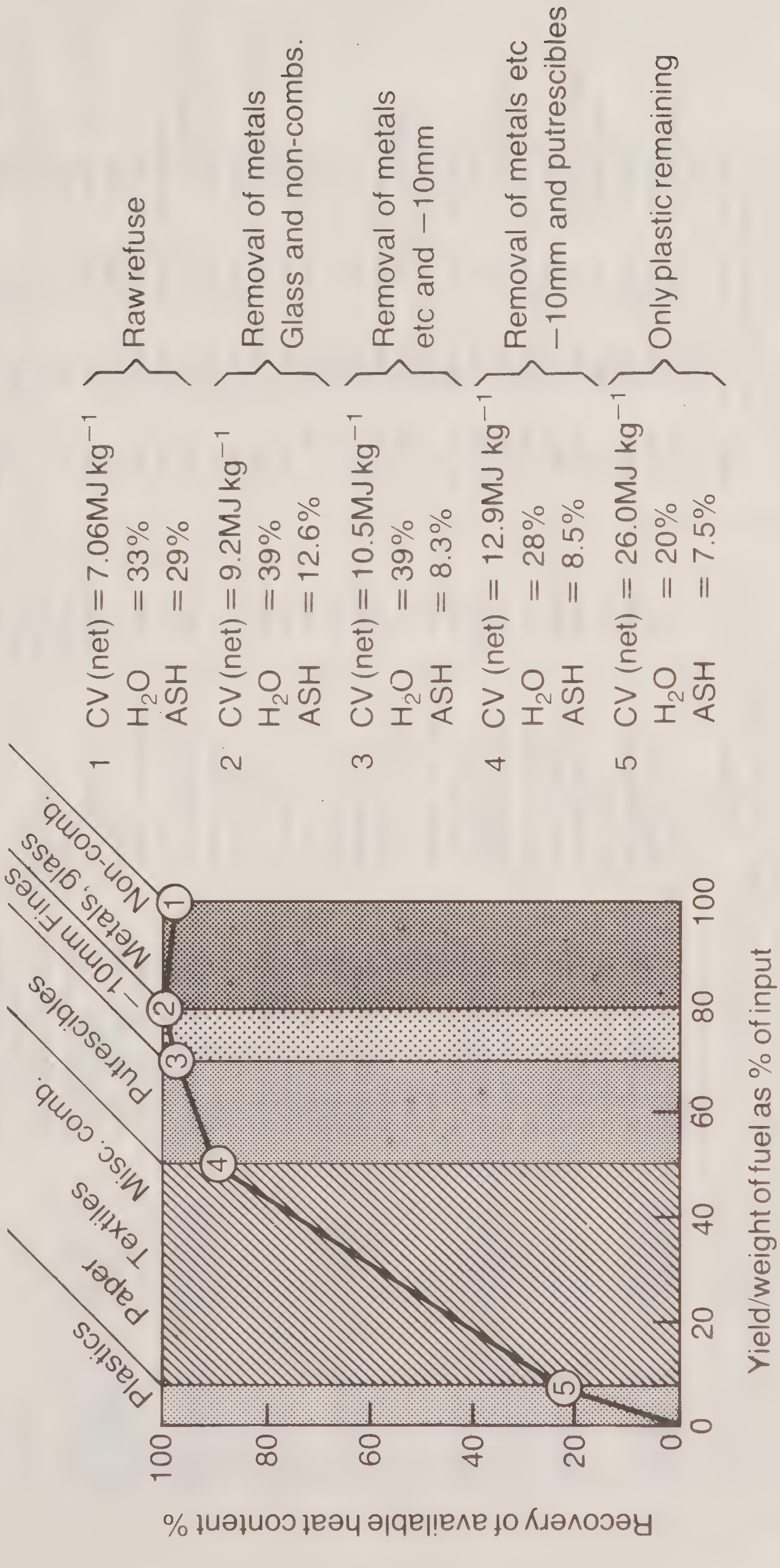


TABLE ONE

LANDFILL GAS COMMERCIAL PROJECTS-ENERGY UTILISATION

26-Aug-88

EXISTING PROJECTS

Gas Production		Utilisation			Actual		Anticipated		
				Date of	Energy Utilisation(tcepa)				
Host Company	Location	Scheme Type	Host Company	Start-up	Dec86	Dec 87	Dec88	Dec 89	
Shanks&McEwan *	Stewartby(1)	Kilns(Brick)	London Brick	1979	1,400	1,400	5,600	5,600	rising
Campbell Brick	Chesterfield	Kilns(Brick)	Campbell Brick	1982	2,160	1,122	2,000	2,000	
Aveley Methane	Aveley	Boiler(Wat.Tube)	Purfleet Board *	1983	20,000	20,000	11,470	11,470	
		Elect(Turbine/3.5MW)	Part Export	1987	NIL	small	7,030	7,030	rising
Yorkshire Brick *	Barnsley	Kilns(Brick)	Yorkshire Brick *	1983	1,200	1,850	2,000	2,250	rising6000
Normanton Brick	Normanton	Kilns(Brick)	Normanton Brick	1983	800	800	850	850	
Bidston Methane *	Bidston	Boiler(Shell)	Premier Brands *	1985	4,400	4,400	5,720	6,000	
Landfill Gas	Ambergate	Boiler(Shell)	Stevenson's Dyers	1985	1,300	707	1,000	1,300	rising3000
Lemace *	Brodsworth	Boiler(Shell)	Lemace *	1985	80	80	80	80	
Blue Circle	Stone(1)	Kilns(Cement)	Blue Circle	1985	20,000	20,000	21,000	21,000	
		Boiler	Britannia Ref.Metals	1988	NIL	NIL	4,000	4,000	
Wimpey Waste	Appley Bridge	Boiler	Tarmac Permanite	1985	600	600	600	600	rising
		Boiler	Tarmac Br. Hydroflex	1986	1,000	1,000	1,000	1,000	
		Elect(Gas Eng/32KW)	Internal	1987	NIL	133	133	133	
Merseyside Waste	Otterspool	Elect(Gas Eng/1.0MW)	Export to Grid	1985	4,150	4,150	4,150	4,150	
ARC	Nuneaton	Elect(Gas Eng/0.5MW)	Export to Grid	1986	2,075	2,075	2,075	2,075	
Cleanaway	Pitsea	Leachate Treatment	Cleanaway	1986	small	890	890	890	
		Elect(Gas Eng/60KW)	Internal	1986	small	249	249	249	
Maltby Brick	Maltby	Kilns(Brick)	Maltby Brick	1987	NIL	570	2,500	2,500	
Shanks&McEwan	Arlesey	Kilns(Brick)	Butterley Brick	1987	NIL	475	1,060	1,060	rising
Shanks&McEwan *	Stewartby(2)	Elect(Gas Eng/0.8MW)	London Brick/Export *	1987	NIL	3,320	4,420	4,420	rising
PEEL	Moriden	Elect(Turbine/3.5MW)	Export to Grid *	1987	NIL	14,525	14,525	14,525	rising
Summerlease	Gerrards Cross	Elect(Dual Fuel/3.0MW)	Export to Grid *	1987	NIL	4,150	12,450	12,450	
Darrington Quarries	Darrington	Elect(Dual Fuel/1.0MW)	Internal	1987	NIL	736	3,700	3,700	
Blue Circle	Stone(2)	Elect(Gas Eng/1.0MW)	Part Export	exp1988	NIL	NIL	4,150	4,150	
Tarmac Econowaste	Allsopps Hill	Kiln-Rotary(Roadstone)	Tarmac	exp1988	NIL	NIL	2,240	2,240	
		Elect(Dual Fuel/2.0MW)	Part Export	exp1988	NIL	NIL	7,855	7,855	rising
LEL/Enercol	Preston	Gas Cleanup/Vehicles		exp1989	NIL	NIL	NIL	240	
		Elect(Gas Eng/2.0MW)CHP		exp1989	NIL	NIL	NIL	8,300	
Cory Waste *	Mucking Marshes	Elect(Turbine/4.0MW)CHP	Local Generator	exp1989	NIL	NIL	NIL	16,600	rising
Marley Tile	Beenham	Boiler	Marley Tile	exp1989	NIL	NIL	NIL	2,110	
		Direct Air Heating	Marley Tile	exp1989	NIL	NIL	NIL	700	
			TOTAL SAVINGS		59,165	83,232	122,747	151,527	

TABLE TWO - DEPARTMENT OF ENERGY - ENERGY EFFICIENCY DEMONSTRATION PROJECTS

PROJECT TITLE	HOST COMPANY	MONITORING BODY	STATUS	INFORMATION AVAILABLE		
				PROJECT PROFILE	EXPANDED PROJECT PROFILE	FINAL REPORT
The Use of Landfill Gas as a Replacement Fuel in a Water-Tube Boiler	Thames Board (now Purfleet Board)	NIFES	Complete	N/A	153	ED/60/153
Landfill Gas Abstraction from a Mounded Site Using Vertical Wells	Bidston Methane	NIFES	Complete	N/A	216	ED/190/216
The Use of Landfill Gas as a Replacement Fuel in a Shell Boiler	Premier Brands	NIFES	Complete	N/A	217	ED/191/217
Landfill Gas Abstraction from a Shallow Site Using Horizontal Wells	Cory Waste	NIFES	Ongoing	233	-	-
Generation of Electricity Using Reciprocating Spark Ignition Gas Engines Fuelled by Landfill Gas	Shanks and McEwan	Ewbank Preece	Ongoing	244	-	-
Landfill Gas as a Boiler Fuel for a Glasshouse	Lemace	NIFES	Ongoing	247	-	-
Electricity Generation from Landfill Gas Using a Gas Turbine	Packington Estate Enteprises	Ewbank Preece	Ongoing	249	-	-
Retrofit Combined Cycle CHP Scheme Incorporating Landfill Gas-Fired Industrial Gas Turbine	Purfleet Board	Thermal Developments	Ongoing	254	-	-
Electricity Generation from Landfill Gas Using Dual-Fuel Diesel Engines	Summerleaze	Electrowatt	Ongoing	298	-	-

TABLE 3: PRINCIPAL PRIVATE WASTE MANAGEMENT COMPANIES

SALES REVENUE COMPANY	DESCRIPTION
£60M CLEANWAY	Handles largest tonnage (about 2mtpa - dominated by household wastes). Provides widest range of services. Also has widest geographical spread. Collection to disposal ratio probably 3:1
SHANKS & MCEWAN	Until its acquistion of London Brick Landfill, SME was medium/small regional operator. Now has largest landfill reserves and is underpinned by important contracts for Greater London household waste. Total tonnage from all service claimed to be over 4m tpa.
£40M BIFFA	Very strong in industrial waste collection and cleansing services. Recently increased its interest in household waste by acquisition.
£30M LEIGH INTERESTS	Strongest industrial waste company. Also controls 75% of hazardous waste treatment market. Negligible household waste. High profile in non-hazardous waste collection.
HALES CONTAINERS	Subsidiary of RMC. Mainly SE based. Strong in industrial waste collection. One of the most profitable companies. No waste treatment.
£15M WIMPEY WASTE	Growing also in SE &Scotland. Mainly industrial waste ouside of the NW.
WASTE MANAGEMENT	Principially NW based, mixed household/industrial collection and disposal. Important and growing presence in SE.
DRINKWATER SABEY	Operates primarily in Yorkshire and SE England, concentrating mainly on collection and disposal of dry wastes. Waste management activies complement mineral extraction interests.
CORY	Subsidiary of Ocean Transport & Trading. Probably two-thirds of income from 0.5mtpa of household waste from Greater London (river borne). Provides hazardous waste solidification service.
£10M ECONOWASTE	Waste disposal division of Tarmac. No waste collection. Predominantly household waste (c600000tpa). Operates 3 important sites which command markets in W&E Midlands and in Lothian Region, Scotland.

ARC	Subsidiary of Consolidated Gold Fields. Disposes of approximately lmtpa. mainly household waste. No waste collection (transport restricted to bulk waste transfer). No third party disposal at its sites.
HARGREAVES	Yorkshire based industrial waste collection and disposal company. Negligible interests in household waste. Has reactivated waste treatment after long period of dormancy.
BCI LANDFILL	Landfill activities mainly SE based. Predominantly household waste: no collection. Lease sites to a number of other operators (including Cleanaway). Near monopoly of void space in Southern Home Counties.

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SESSION 6

NOISE

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DEVELOPMENTS IN THE BUILDING REGULATIONS FOR SOUND INSULATION

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Introduction

National Building Regulations were first implemented in the UK in 1965. The sound insulation requirement was that the sound insulation for separating walls and floors should be 'adequate' and the Regulations included a short list of constructions that were deemed-to-satisfy the requirement. There were no restrictions on flanking construction, nor was there any alternative way of complying with the requirements.

The first revision was in 1972. The deemed-to-satisfy list was retained but restrictions on the flanking construction were added and also an alternative approval procedure was given. This allowed a basic design that had been built, tested and shown to comply with the performance standard to be approved for use on other sites. The problem with this procedure was the possible difficulty of getting approval to build the first example.

In 1985 a major review resulted in important changes in the way sound insulation regulations are specified. The actual Regulations were reduced to simple functional requirements (eg that sound insulation should be reasonable) supported by technical guidance in separate Approved Documents (AD). This system has the advantages of simplicity and greater flexibility and enables the technical guidance to be updated more readily as better information becomes available. For sound insulation, the technical content was updated and clarified in 1985 but few major changes were made.

The technical content of the Regulations is now being reviewed. The existing information will be updated and two new sections are being considered. One of these describes an additional approval procedure based on full size laboratory mock-up tests. This is intended to simplify gaining approval for innovative designs. The other new section deals with extending the Regulations to cover flats that have been made by converting houses.

At this time we have to take account of the pending

European Directive on Construction Products and the need to harmonise the UK Regulations for Scotland, Northern Ireland and England and Wales.

New Buildings

Apart from changes to the AD required to take account of technical developments, other changes are required to harmonise requirements and remove barriers to trade within the UK. At the present time England and Wales use the 1985 Regulations (1), Scotland has Regulations that are generally similar but in some cases more stringent (2), and Northern Ireland is still using the 1972 English Regulations. It is now proposed that an updated version of the technical part of the Scottish Regulations for new building should be adopted by England and Northern Ireland. There will still be differences between the approval procedures, in particular England will not accept post-construction testing, but the constructions described in all three documents should all be the same as far as possible.

The new AD for England and Wales will therefore contain changes to keep it up to date and also to bring it into line with Scotland. There will be many minor changes but the main changes being considered are:

(a) increasing the mass of blockwork cavity wall from 250 kg/m^2 to 300 kg/m^2;

(b) increasing the mass of the floating concrete floor from 220 kg/m^2 to 300 kg/m^2;

(c) adding a new cavity wall with independent linings.

Additional Approval Procedure

A difficulty with the current approval system is that it makes no provision to allow innovative new designs to be built. To solve this problem we have proposed a test for combinations of separating wall and external wall in a two storey mock up. Including the external wall in the test is to ensure that the main flanking path is taken into account. The procedure will include recommended room dimensions

which give a volume close to 45m (Figure 1). This volume was chosen as being large enough for reliable measurments, yet small enough to be representative of a dwelling. Other dimensions may be used but a correction is provided to make results comparable.

An obvious weakness of the test is that building work can be undertaken to an untypically high standard so it is possible that performance will be above average for the type of construction tested. Extensive field measurements have shown that for most types of construction the best examples are about 4 dB ($D_{nT,w}$) better than the mean for each type. For the AD, constructions are required to have a mean insulation of at least 52 dB ($D_{nT,w}$). so that the best examples of a construction just meeting this requirement will have an insulation of about 56 dB. Consequently we have proposed that to pass the new test both pairs of rooms in the mock-up should have an insulation of at least 55dB.

Conversions

The major addition proposed for the AD is a new part covering flats converted from houses. An important decision is what level of insulation to accept as reasonable. Ideally it would be the same as that for new build. However, with new work flanking transmission can be taken into account. With conversion work as much of the existing structure as possible must be used for the job to be economically attractive. This rules out extensive work to control flanking transmission such as wall linings. The result is that in the common situation where the existing construction includes 100mm thick brick walls, the insulation is limited to about 50 dB. Although this value is lower than that required for new work, it represents an improvement of at least 10 dB so noise levels will be roughly halved.

The actual values proposed for the weighted standardised level difference ($D_{nT,w}$) are 49 dB for walls and 48 dB for floors and the value of the weighted standardised impact sound pressure level ($L_{nT,w}$) is 65 for floors. These values are the same as those already specified as minimum values for individual constructions in the new build section, so they have an established basis as well as reflecting practical

limitations.

The new section of the AD describes one remedial treatment for walls and five for floors. Of the floor treatments, the first three are intended for normal use and the other two, which give lower performance, are only for use where practical constraints rule out the first three.

Wall treatments

The recommended treatment for walls is the familiar independent wall lining. Any type of supporting frame can be used to support two layers of plasterboard providing the cavity is at least 25mm wide and contains absorbent. The narrow cavity should avoid the problems of making shared hallways too narrow.

Floor treatments

The three preferred floor treatments are shown in Figure 2. They are: the independent ceiling, the platform and the raft type. Obviously the floor element must provide better insulation than the flanking construction or the net insulation will be lower than the limit set by flanking transmission. The choice of resilient layer is particularly important for the raft type. Laboratory tests have shown that mineral fibre 25mm or 30mm thick and having a density of at least 80 kg/m is suitable. The performance of less dense types may deteriorate when the floor is loaded with furniture. For example, a floor using a 13mm thick layer of glass fibre with a density of 36 kg/m^2 was tested with and without a load of 100 kg/m^2. The airborne insulation deteriorated by 8 dB and the impact transmission increased by 6 dB. With the denser material the deterioration was reduced to 2 dB in both cases. This is shown in Figure 3.

Building Regulations

The problem with these solutions is that either the ceiling level is lowered or the floor level is raised. In some situations, such as in listed buildings, these considerations make the preferred solutions impractical. In these cases, with the agreement of the local authority, the lower

performance solutions can be used. These are a simplified floating floor and an independent joist type with the new joists between the original.

Laboratory and field tests

In addition to the constructions described in the AD there will be provision for proprietary systems to gain approval either by laboratory or field tests. As flanking transmission is not controlled a special test laboratory, of the type decribed for new build, is not required and tests can be done as described in BS2750: 3. The values required from laboratory tests are higher than those required from field tests to allow for flanking transmission.

Survey

These measures should greatly reduce the incidence of poor sound insulation at acceptable cost. We hope to conduct a social survey after the new Regulations have been in operation for a reasonable time to see how effective they are.

Acknowledgement

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References

(1) The Building Regulations 1985. Approved Document E, Sound, Department of the Environment, HMSO 1985.

(2) The Building Standards (Scotland) Amendment Regulations 1987, Part H, Resistance to the transmission of sound.

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QUIET DESIGN IN BUILDINGS

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INTRODUCTION

At the completion of any building project, whether a starter home or a new international airport, the resulting acoustic conditions are an inevitable consequence of design and construction. In resolving the sometimes conflicting requirements of the various disciplines, it is easy to lose sight of the repercussions that some design decisions have on noise control. The result is to arrive unintentionally at a particular noise climate in and around the completed project. Often this will prove adequate but where it does not it may be extremely disruptive; and to attempt to improve conditions retrospectively may be costly.

Noise control should not be regarded so much as an exceptional requirement, restricted to a few key risk areas, but more as a parameter that influences design at all stages from site selection through to detailing and implementation. Noise levels can often be predicted with reasonable accuracy for many sources and therefore quiet design can be carried out at the drawing board.

Quiet Design can be incorporated successfully in most projects; the technology is generally available even if its wide usage currently cannot be claimed. The process must involve a clear brief, and an appreciation by all members of the design and construction team of the underlying physical principles of quiet design. Noise control measures must be implemented with considerable care, as apparently insignificant deficiencies, can spoil the result.

In this paper the principles of quiet design are given together with some illustrative case-studies. It concludes with a general consideration of future trends and of society's increasing need for quiet design.

THE PRINCIPLES OF QUIET DESIGN

The principles of quiet design require firstly a clear definition of the Client's requirements. From this (often verbal) brief, the acoustic designer can develop numerical requirements and work with the design team to ensure that the necessary measures are incorporated. The quiet design process involves ensuring that these measures are implemented correctly on site, and that all criteria have been achieved by the time the building is handed over to the Client.

The acoustic designer has available to him several tools[1], for instance,

- Good Planning
  (eg Do not put the kitchen of one flat over the bedroom of another.)

- Appropriate Sound Insulation
  (eg Specification of an airtight wall construction with an appropriate combination of mass and isolation to achieve the required sound insulation.)

- Appropriate Sound Absorption
  (eg Use of a highly absorbent ceiling in an open plan office to reduce a reflected sound path between work stations separated by a screen.)

- Appropriate Vibration Isolation
  (eg Use of resilient mountings to reduce the transmission of machinery vibration into the building structure.)

- Selection of quiet machinery and plant[2]
  (eg Air Conditioning Equipment, by Machine Design.
  eg Use of Concrete Nibblers rather than Impact Tools to reduce Construction noise during demolition of concrete.)

To appreciate the way in which these principles can be used, a few examples are briefly discussed.

Project A:

A Client found a small area in the basement of his existing music college in which he could locate some practice rooms. He briefed the designers that not only were the two rooms to be close to each other, but that they must allow practice by percussion instruments in room 1 and brass in room 2 without disturbance to each other or other sensitive rooms on higher floors. The brief was clear, and definitely challenging.

The acoustic designer computed from the typical playing sound levels, the inter-room sound insulation required. The high numerical requirement necessitated the use of heavy walls separated by a large air gap, containing acoustic absorbent to reduce acoustic coupling. The high sound insulation performance of these heavy walls was maintained by use of neoprene vibration isolators, so avoiding vibration coupling between the walls. Attention to detail was necessary to avoid holes in walls, above walls, around doors etc. The resultant construction is shown in Figure 1 and the measured sound insulation performance in Figure 2. Though it was only possible to measure the final result over a restricted range of frequencies, it can be seen that the mid-frequency results corresponds to approximately twice that of a domestic party wall, ie approximately 100dB.

Project B:

A Client found that the sound insulation between flats in a new development was significantly less than expected. His brief was to improve the sound insulation to bring it up to good UK standards(3).

The brief was clear. However, the reasons for the on site problem were unclear. The quiet design therefore started with testing on site to determine the prevailing conditions, so that computations could be made of the effect of possible improvement measures. The poor on-site result was due both to an inadequate design together with numerous small constructional defects. These defects were not of significance to a structural engineer, a builder, or an architect but they included small holes through the party wall of great

significance to the acoustic designer. To resolve these and other problems, the acoustic design required the sealing of all gaps and the introduction of a free-standing laminated plasterboard panel. The before and after constructions are shown on Figure 3, the consequential sound insulation performance, Figure 4.

Project C:

A Client obtained, on favourable terms, a busy urban site on which to build an Academy for the Performing Arts(4). Around the site was a six lane highway on one side, an elevated highway on another side, a helipad nearby, and two Underground railways tunnels 20m below. Inside the building, quiet conditions were required for study and performance.

The project involved many complex acoustical problems. The acoustic design process is illustrated here by just one of the spaces which was symptomatic of the problems experienced elsewhere. The hall in question was to be suitable for the performance, rehearsal and recording of orchestral music. It was by architectural dictate located above the two Underground tunnels which were straddled by the piles of the building.

In this case the brief was clear, however the translation of the brief from lay to numerical/technical terms was difficult. This related to the differing requirements of recording and music performance and, to some extent, to cost constraints.

The acoustic design process involved detailed vibration measurements on site as the piled foundation and superstructure in which the hall was to be located grew. The consultant worked with the design team to produce within the building a heavy sealed vibration isolated hall. The design was based on a box-within-a-box using the principle of structurally-isolated masonry walls to control sound transmission into the hall. Specialist vibration isolators were used to limit the structure-borne sound from the Underground trains passing through the massive structure into the hall, see Figure 5.

Despite considerable care in design and implementation first

site results were disappointing both to the consultant and the Client. The missing factor had been the necessity for the acoustic designer to check that his constructional requirements had been implemented correctly. The author spent three days exploring the 2ft wide void that separated the heavy hall from the surrounding building structure. Numerous small elements were found that bridged between the so called isolated hall and the main building elements. These small elements were considered trivial by the site staff, as they could not believe that such small features were of importance. Despite general disbelief, the acoustic designer insisted that all these elements were severed, and the predicted improvement in conditions was achieved. See Figure 6.

Faith was restored in acoustic design, and the first recording engineers to use the facility did not even detect the presence of the Underground.

Project D:

A Client wished to develop land for a new Airport, and sought advice on the impact[5] that would arise from such an airport and the necessary noise control measures to mitigate any effects.

The brief was clear, however its translation into numerical criteria was complex. Despite this it was found that certain noise control measures were desirable if the airport was to be approved and built. In particular the acoustic design process led to a recommendation for an effective noise barrier along the apron of the airport to reduce noise on nearby properties, Figure 7. This design proposal was supported by the planning authority, implemented by the Airport design team and recently tested by the author. Figure 8 shows the predicted and measured performance of the barrier.

General Past Experience

These personal examples are just a few of the many successes that have been achieved in recent years by acoustic design. Progress in quiet design is also evidenced

by successes in the control of noise from individual aircraft and road vehicles, as the following examples illustrate:

Aircraft Noise:

Small Passenger Jet	Approach Noise (EPNdB)
H S : Trident	110
B Ae : 146	95

Passenger Propeller Aircraft	Approach Noise (EPNdB)
H S : 748	103.8
B Ae : ATP	93.0

Road Traffic Noise

		Noise (dB(A) at 7 metres)
Heavy Lorries:	(Initial Limit)[6]	91
	(From 1st October 89)	84
Private Car:	(Initial Limit)	84
	(From 1st October 89)	77

The degree to which acoustic design will be allowed to produce quieter conditions in future will be determined by the demands of society. In the heydays of the 70's, environmental concern was a leading issue and great advances were expected. In the intervening years, progress has been limited despite this optimism. James Seebold writing in Noise Control Engineering Journal[7] talks of the implementation failure of environmental noise reduction in the United States, viz

> "The ultimate failure and dissolution of the federal noise control program in the United States of America made a mockery of the Noise Control Act of 1972 and the Quiet Communities Act of 1978".

The Noise Council's[8] recent conclusions on effectiveness of noise legislation on Noise Control give a similar message, for

instance the conclusion states,

> "4. The Building Regulations dealing with sound transmission between dwellings are a clear demonstration of the failure of legislation to prevent noise problems".

It is likely that the failure to meet expectations relates more to the Client not asking and insisting on his wish for peace and quiet than the lack of availability of acoustic design techniques.

GUIDES TO THE FUTURE

Within the Home

From Neighbours via Party Walls

o No improvements in regulatory standard under consideration, increased use of equipment in homes, televisions throughout homes, and more powerful hi fi devices.

Trend: No improvement, possible worsening.

NB Recent Trend:
Complaints to Environmental Health Offices about domestic noise:
1975, less than 200 complaints per million population
1985, greater than 1200 complaints per million population.

At Home from Environmental Noise

From Road Traffic

o Vehicle engine noise is being reduced in response to legislation. This is of greatest benefit in urban situations where the traffic is slow-moving.

If policy makers back EEC directive, sound levels for new vehicles will have to achieve 10dB(A) in the period

1980 to 1990.

- o Noise of vehicles near motorways (freely flowing traffic) is dominated by tyre noise.

  No reduction yet, new road surfaces, used abroad, offer 4dB(A) reduction. If not adopted in UK no reduction in noise of vehicles on motorways.

  Volume of road traffic expected to continue to increase

1975	206*
1985	285
1995	360
2005	410
2015	452

* All Motor Traffic (Thousand Million Vehicle Kilometres)

This is the national average traffic projection, issued by the Department of Transport in April 1985. Local situations may have lower or higher growths.

NB In 1987, road traffic increased in one year by 5%, well in excess of forecast above.

<u>Trend:</u> Some improvement in the urban situation, slight worsening near motorways.

<u>From Air Traffic</u>

- o The development of more fuel efficient and quieter engines has led to a significant reduction in the noise of individual aircraft types.

- o The major reductions in individual aircraft noise have now occurred (Airbus, B Ae 146, Boeing 757, Boeing 767 etc). The next few years will see the continued withdrawal of some of the slightly noisier types plus the effect of traffic growth.

- o The number of aircraft movements has increased

dramatically, especially in the last few years.

o The latest fuel efficient engine, the advanced counter-rotation turboprop(9) has problematic noise characteristics during cruise conditions.

Volume of Traffic:

IATA reports:-

Commercial Air Transport Movements in Western Europe:

1987 - 3.3m
1988 - 3.5m
1989 - 3.7m
1990 - 3.87m
1991 - greater than 4m

Schiphol Airport, Holland, Growth in 1987

13.8% passenger traffic overall

Belfast International Airport in 1st April 1987-88

14% passenger traffic growth

Birmingham International Airport in 1987

25.8% passenger traffic growth

Gatwick International Airport in 1987

10% air transport movements growth

Department of Transport Projections, issued May 1987, during the floatation of BAA:

Four London Airports (Heathrow, Gatwick, Stansted, Luton)

1986	50.1*
1990	57.5/66.3
1995	68.4/89.0
2000	80.0/114.6

*Million passenger per year; low/high forecasts

Median projection, 1986-2000, growth of approximately 75%

(Actual figures for 1st April 1987-88, 58.9)

<u>All Other UK Airports</u>

1986	25.0
1990	25.7/32.6
1995	29.6/43.1
2000	33.8/54.8

*Million passengers per year; low/high forecasts

<u>Trend</u>: Some improvement at certain airports where growth potential is limited, eg Heathrow, slight worsening possible at other airports.

<u>From Rail Traffic</u>

- o No figures are published nationally for the development of rail traffic, although it is presumed that the Channel Tunnel will assist in developing rail traffic especially in Kent, and also on the routes for freight and passengers to the rest of the Country.
- o Commuter traffic into Central London is expected to increase by 20% in the period 1987-1997.
- o It is expected that on some routes, faster and noisier trains will arise.

<u>Trend:</u> No great change, but some worsening, especially in Kent.

<u>From Industry</u>

Complaints received by Environmental Health Officers about industrial and commercial noise have increased.

1975, 160 Complaints per million population

1985, 600 Complaints per million population

Trend: Some worsening.

At the Workplace:

Industry

- The control of occupational noise exposure has been supported by legislation since the 1961 Factories Act, and its famous replacement, the 1974 Health and Safety at Work etc Act.

- The Noise Council in 1987[8], wrote
"the existing regulations have only been applied sporadically and inconsistently .... The problem does not appear to have been lack of legislation, but lack of enforcement due to the depletion of the strength and resources of the Factory Inspectorate at area level".

Trend: No forseeable reduction in noise at work.

Office

The advent of batteries of visual display units, keyboards, computers around the high tech dealing desks results in a noisier environment for the market makers than hitherto.

- Open plan offices continue to find favour with developers. There is still no sign that the principles of acoustic design to maximise privacy and minimise disturbance from fellow-workers are being widely adopted.

- The design of cellular offices is currently dominated by the apparent flexibility provided by demountable partitions. Tenant fit-outs are now commonplace. Manufacturers continue to develop their own products and publicise their acoustic properties. However, the combination of a number of products (partition, suspended ceiling, computer floor, building cladding, mechanical services ducts and diffusers) on site often results in unsatisfactory performance.

- The future development of speech controlled machines will require a return to more pleasant conditions as the machine may be less able than the human to operate in a cacophonous atmosphere.

Trend: Little real improvement.

CONCLUSION

The overall trend appears to be for environmental noise to increase over the next few years. The increase is likely to be small, however. Expressed in terms of Leq (the acoustic unit currently in favour), a general increase corresponding to 3dB might occur - though local conditions may fluctuate greatly. If, over the same period, all the tools of quiet design are used, they can more than compensate for this small increase at source.

Conditions at work and within the home will also require the widespread and consistent application of acoustic design, otherwise conditions are likely to worsen.

Whether acoustic design will be utilised in practice is an open question. A clear expression of society's needs is required as was expressed in 1963 in the Wilson Committee Report. I offer for your consideration the recommendation of the House of Lords Select Committee on Science and Technology that a review of the Wilson Report should now be made. With the benefit of 25 years further experience, the revised report would establish society's goals and the principles to attain them.

REFERENCES

1. Sound Control for Homes, Report 114/115. CIRIA 1987.

2. Sound Control: CIBSE Guide B12, The Chartered Institute of Building Services Engineers, 1972.

3. Approved Document E1/2/3, the Building Regulations 1985, Airborne and Impact Sound, DOE, HMSO London.

4. The Academy for Performing Arts, Hong Kong, Paper E3-4, 12th International Congress of Acoustics, Toronto 1986.

5. London City Airport - Avoiding a Problem at Britain's Fist Stolport, by P Henson and J G Charles, Institute of Acoustics, Conference: Urban Transportation Noise, May 1988.

6. Motor Vehicles, Construction and Noise Regulations, 1970/1980, HMSO and E C Directories, 70/157/EEC, 77/212/EEC and 78/1015/EEC.

7. J G Seebold, Noise Control Engineering Journal, January - February 1988.

8. Noise Legislation - Its Effectiveness for Noise Control, The Noise Council, Chadwick House, London 1987.

9 Cruise Noise of an Advanced Counterrotation turboprop measured from an adjacent aircraft, by Richard D Woodward et al, NASA, Noise-Con 88.

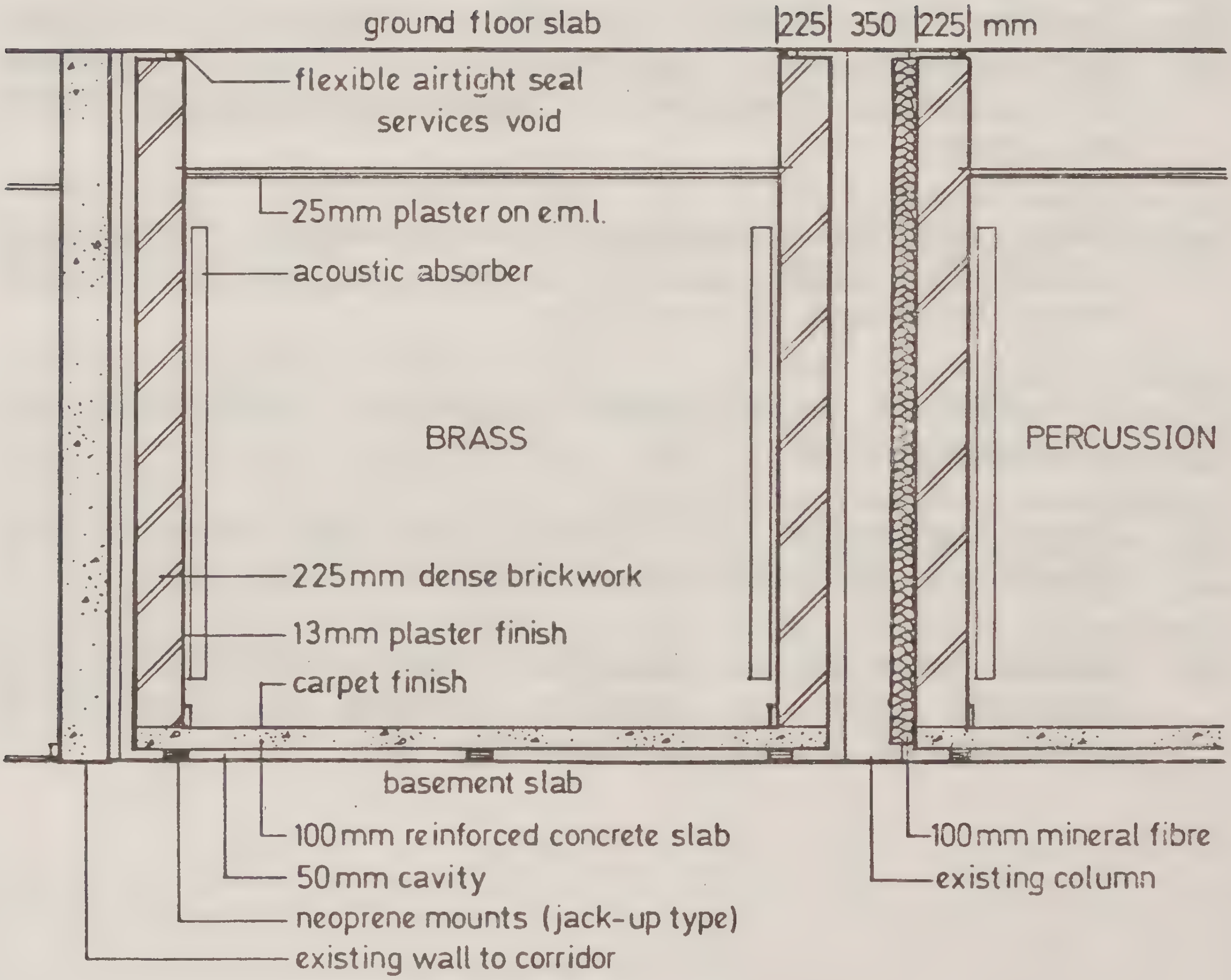


Fig.1: Construction of New Practice Rooms: Project A

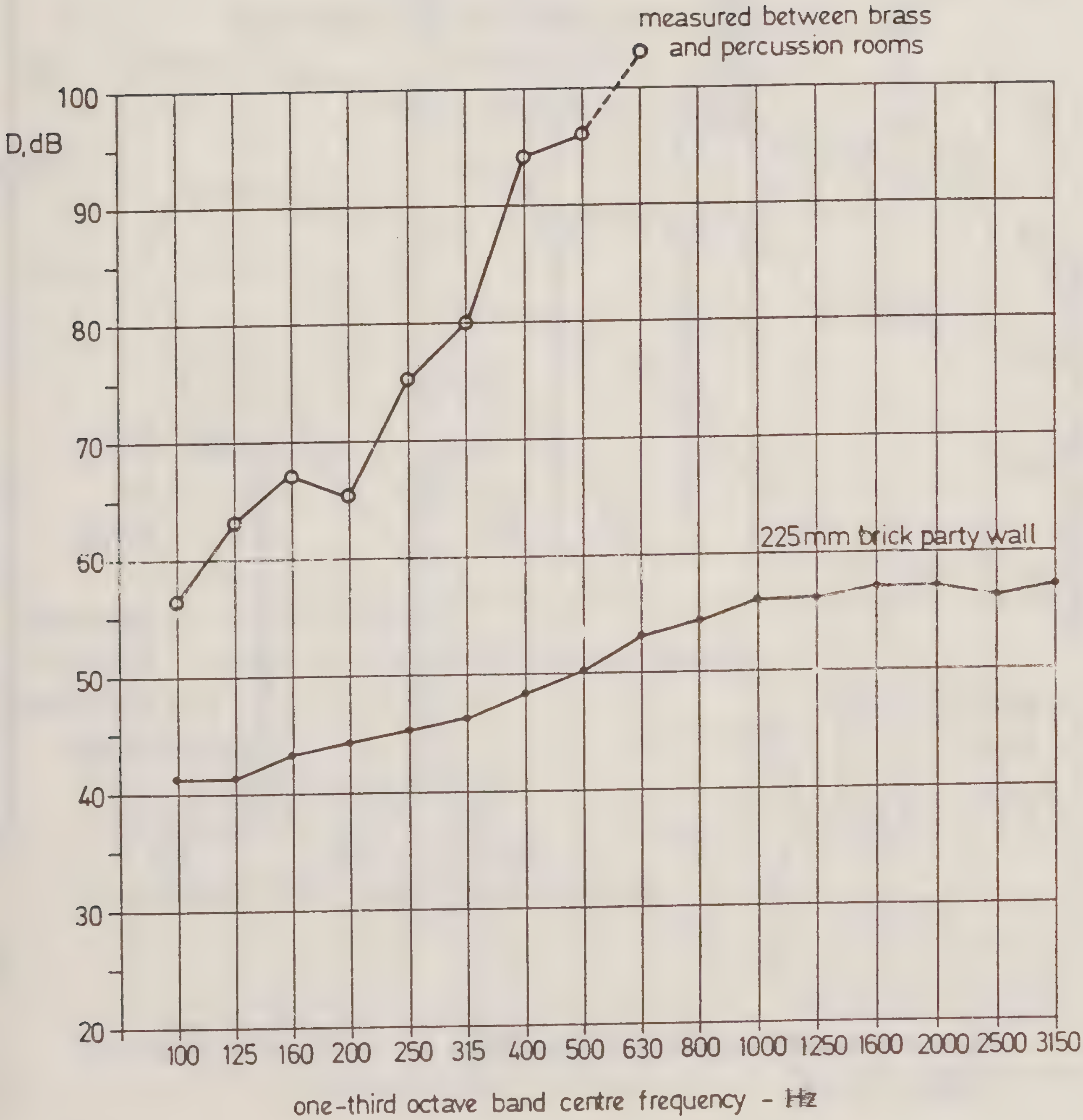
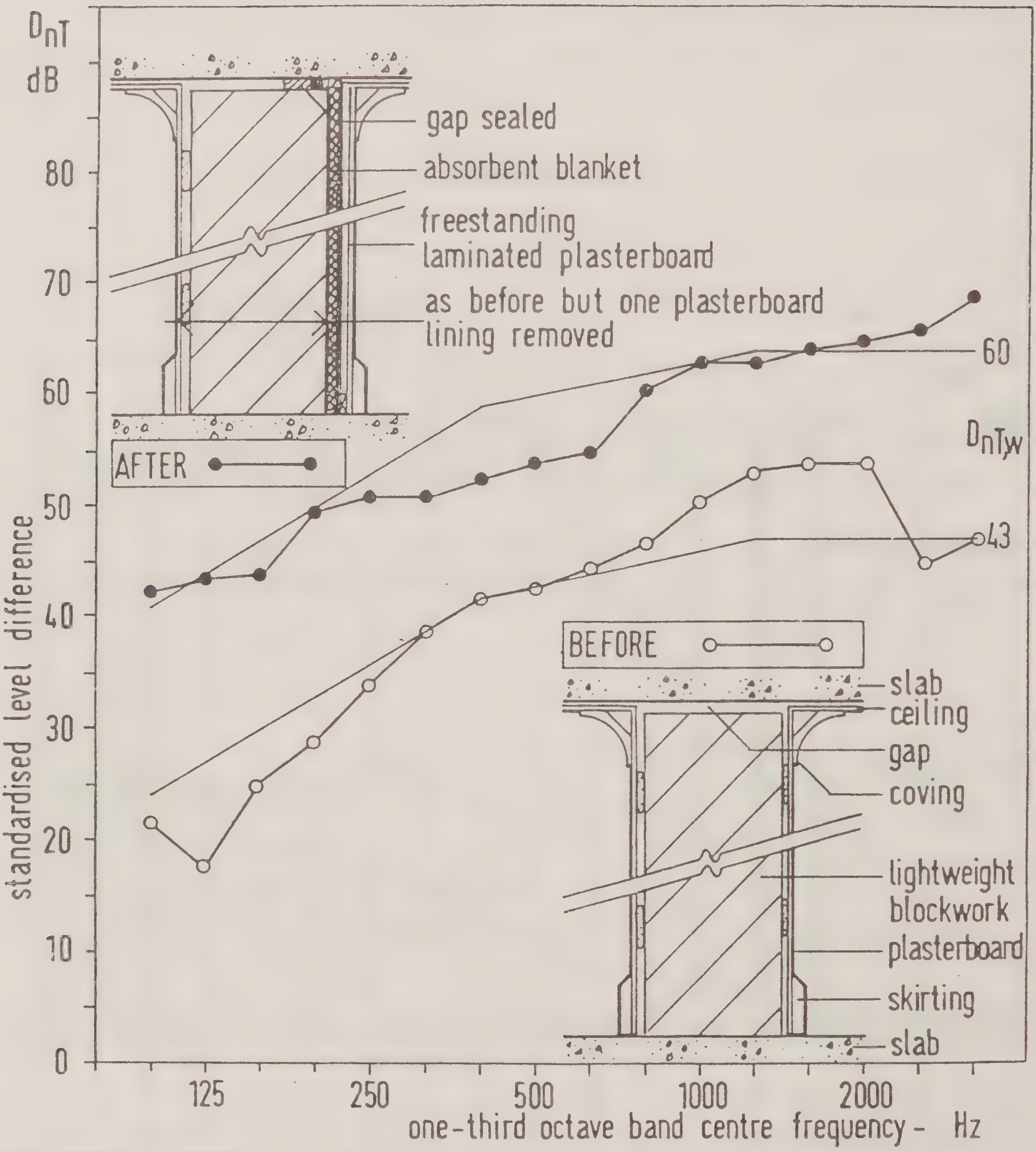


Fig.2: Sound Insulation between Practice Rooms: Project A



Airborne sound insulation improvements to a dry-lined blockwork separating wall

Fig.3: Before/After Party Wall Constructions: Project B. Sound Insulation between Flats: Project B

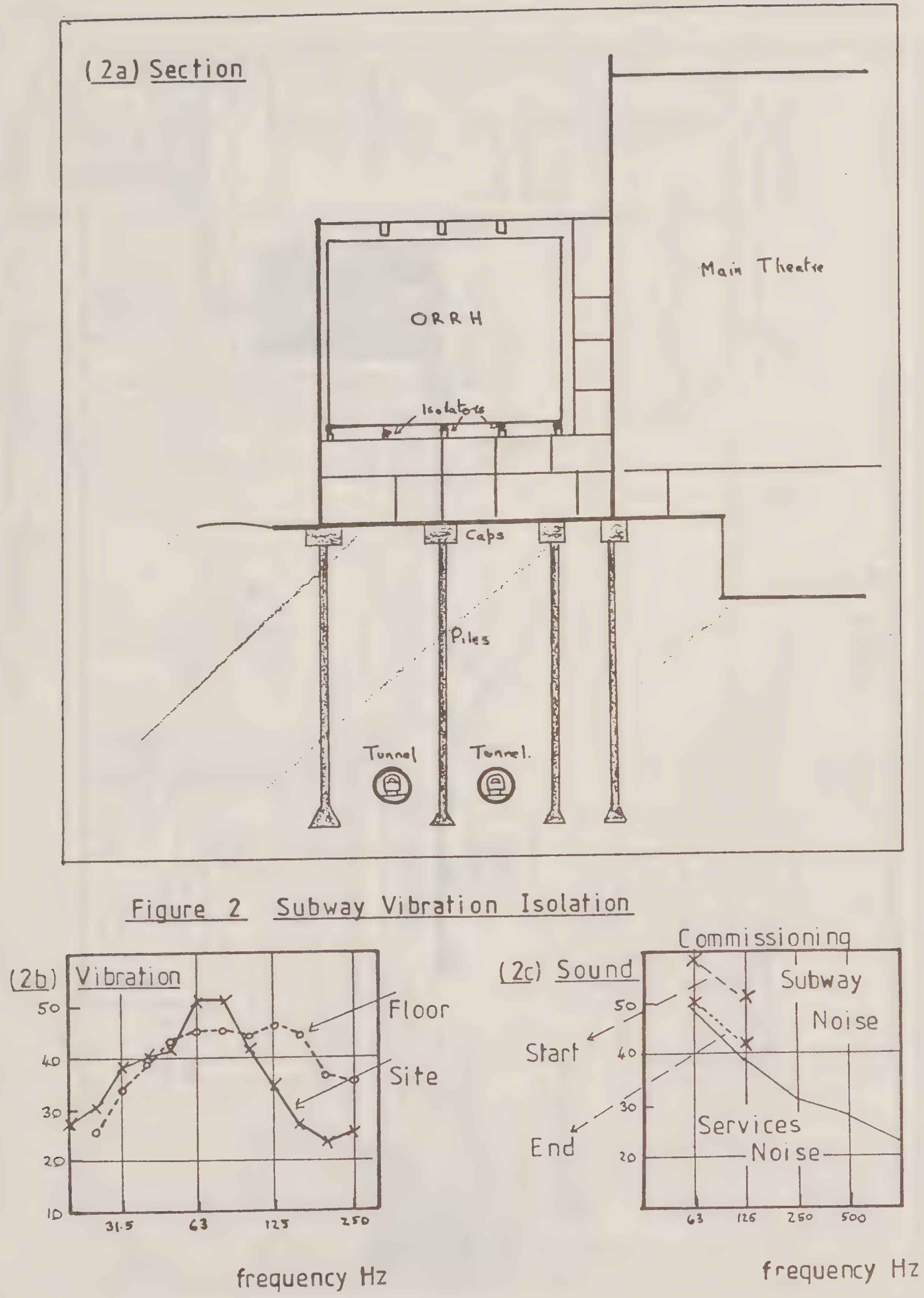


Fig.4: Construction of Hall above Underground: Project C. Sound within Hall from Underground: Project D

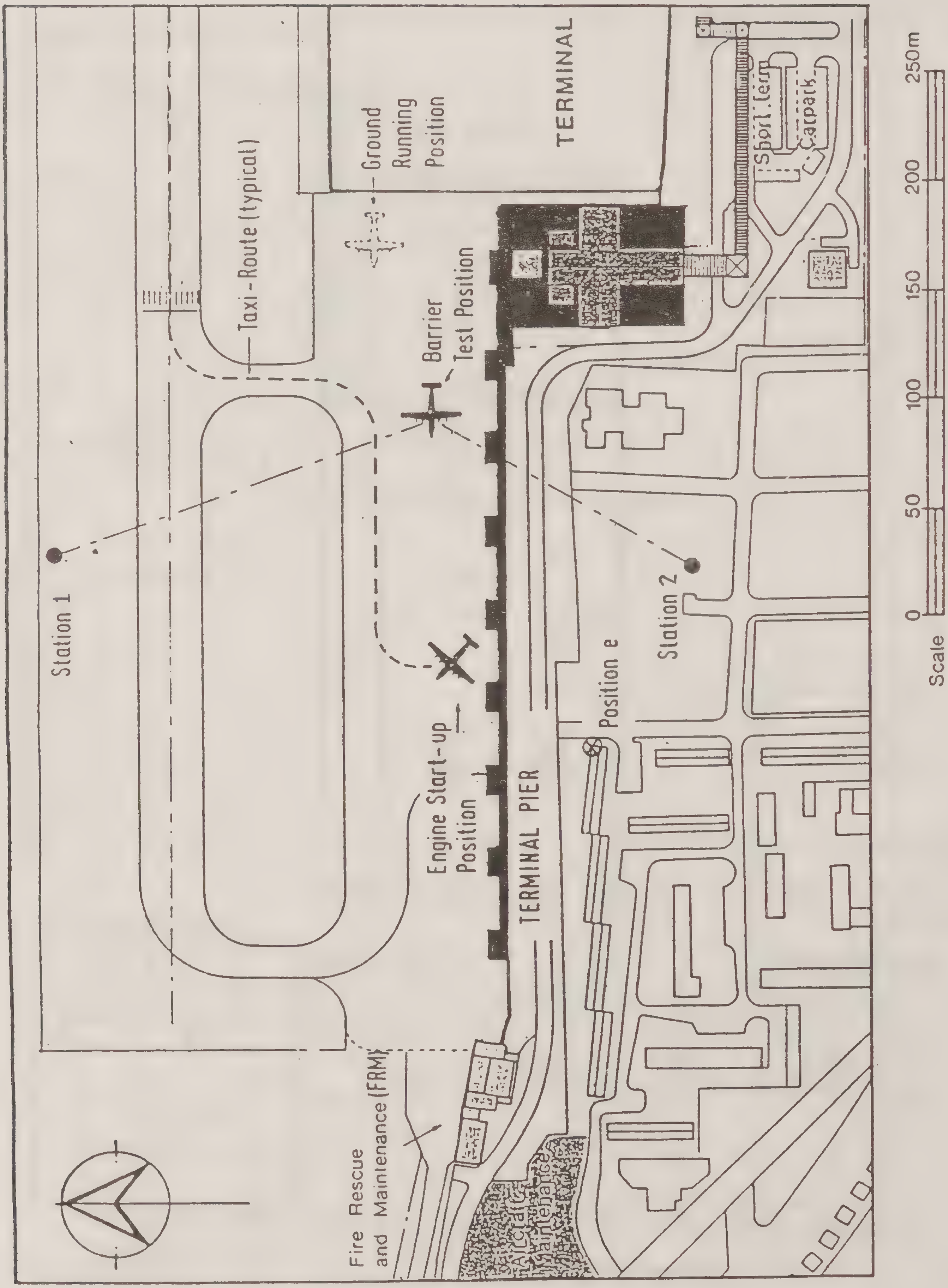


Fig.5: Noise Barrier at London City Airport: Project D

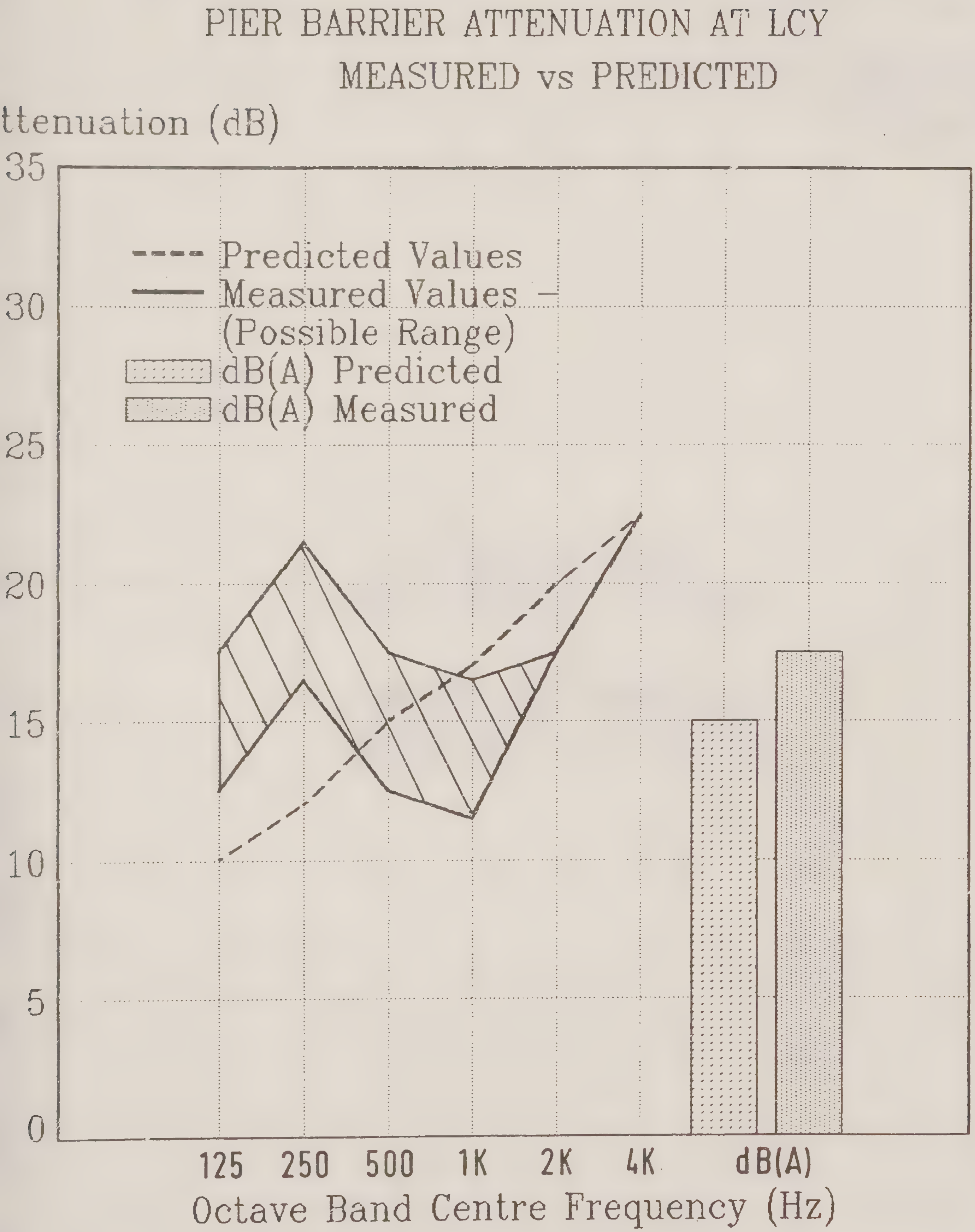


Fig.6: Predicted and Measured Performance of Noise Barrier: Project D

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A NOISE TEST FOR MOTOR CYCLES

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1. Introduction

The motor cycle, in a recognisable form, has been a feature of road traffic for over 80 years and it seems, that for most of that time, it has been the subject of complaints about excessive noise.

It is however only during the past 20 years or so that motor cyclists have worked their way into a position of such prominence that, if surveys are to be believed, they are now considered by many people to be a major cause of noise nuisance and where, according to the Department of Transport, the proportionately very small numbers in road use give rise to a totally disproportionate number of complaints.

Leaving aside the somewhat questionable social aspects of the general public's conception of motor cycles and motor cyclists, there are a number of good engineering reasons why motor cycles are noisier than private cars, the sector of road traffic with which they are most usually compared.

Firstly, modern motor cycle engines tend, size for size, to be much more powerful and faster revving than those of private cars, and secondly, the physical layout, configuration and cost of the motor cycle, tends to preclude the effective enclosure of the engine and imposes limitations upon the size and design of exhaust silencer that can be fitted.

Nevertheless motor cycles can be made to conform to acceptable standards of noise emission, and will, like all vehicles in road use in this country, have complied with the legislative standards of noise emission that were in force at the time of their manufacture. Such standards were at the time of their introduction considered to represent an acceptable level of noise, and thus it may be inferred that motor cycles with exhaust systems and silencers that meet or exceed the acoustic specification of the machine's original equipment produce acceptable noise levels.

From this premise it can also be inferred that the unacceptably noisy machines in present use, which presumably

cause the complaints about noisy motor cycles, are fitted with either defective or ineffective exhaust systems. Therefore it can be argued that the problem of motor cycle noise could be resolved by the elimination from road use of all those machines that are fitted with defective or ineffective exhaust/silencer systems.

This simple proposition has obviously been considered by both the Department of Transport and the Police Authorities in the UK, and the Department of Transport has already imposed restrictions upon the sale of sub-standard motor cycle exhaust systems. However, unlike continental countries, and notably Sweden, no attempt has been made by government bodies to introduce a road side test that will distinguish between a noisy motor cycle and one that produces acceptable levels of noise.

This paper details the results of an investigation carried out by Derby City Council and by members of the Noise Committee of the National Society for Clean Air, and suggests one simple, practical method for measuring the noise levels of in-use motor cycles.

2. The Legislative Standards for Motor Cycle Noise and their Application

The legislation governing the 'in use' noise levels of road vehicles is the Construction and Use Regulations 1986.

These regulations, unlike earlier Construction and Use Regulations, do not specify a method of measuring 'in use' noise levels for road vehicles. This is not however the great loss that it might at first appear, because it is widely considered that the methods specified in earlier Construction and Use Regulations were so complex as to be unworkable.

Regulation 54(1) of the Construction and Use Regulations 1986 does however state:

'Subject to Paragraph (2) every vehicle propelled by an internal combustion engine shall be fitted with a silencer and the exhaust gases from the engine shall not escape to atmosphere without first passing through the silencer.'

Regulation 54(3) further requires that:

'A silencer shall be maintained in good and efficient working order and shall not be altered so as to increase the noise made by the escape of exhaust gases.'

The noise emission from motor cycles is covered by Regulation 57 of the Construction and Use Regulations, and in particular by Regulation 57(3) which states:

'The silencer which forms part of the exhaust system of a motor cyle first used on or after 1st January, 1985 shall be either:

(a) That with which the vehicle was fitted when it was first used; or,

(b) Clearly and indelibly marked with either:-

(i) The Relevant British Standard marking indicating that it has been tested in accordance with Test 2, or;

(ii) A reference to its make and type specified by the manufacturer of the vehicle'.

Older motor cycles, that is those used after 1st April, 1970, must be able to meet the standards of noise emission laid down in the Regulations and which are detailed in a Table contained in the Regulations.

These regulations recognise that motor cycles fitted with standard exhaust/silencer systems, in good condition, produce acceptable levels of noise, and it seems, are intended principally to perpetuate this state of affairs.

Further legislation, designed to reinforce this concept, has now been introduced. This legislation, the 'Motor Cycle Noise Act 1987' was derived from the private members bill introduced by Robert Adley MP, and it and the accompanying proposed 'Motor Cycle Exhaust Systems Regulations 1988' are

intended to prohibit the supply of replacement exhaust systems that do not meet either the performance requirements of BS AU193 or the manufacturer's original specification.

The Construction and Use Regulations 1986 and the Motor Cycle Noise Act 1987 appear in theory to be capable of a significant impact upon the problem of motorcycle noise. However in practice the effectiveness of this legislation will depend upon the way it is applied and the vigour with which it is enforced.

This legislation will only work properly if the Trading Standards Departments can ensure that only systems which meet the appropriate standard and are correctly marked are offered for sale, and if the Police can make available the manpower required to ensure that motor cycles in road use are fitted with silencers that comply with the requirements of the Construction and Use Regulations 1986.

The task of the Trading Standards Officers will not be easy, but it will be simple when compared with that of the Police. In order to ensure compliance with the Regulations, their Officers and presumably MOT Testers, will have to ensure that all machines first used after 1st January, 1985, are fitted with either the original or the appropriately marked replacement exhaust systems that conform to Section 54(1) and (3) of the Regulations and in addition that motor cycles first used after 1st April, 1970 produce levels of noise that do not exceed the values set out in the Regulations. Not all modified exhaust systems in road use are as blatantly obvious as that illustrated in Figure 1. Furthermore, silencers may deteriorate internally without external indication of their failure or a machine may be fitted with a replacement silencer that does not have the acoustic performance of the original equipment. The enforcement of existing and forthcoming legislation will therefore be complex and problematic and, given the existing commitments of the Police and the other authorities involved, there must be some question concerning its accomplishment - particularly in the absence of any practical test to determine the noise level of 'in use' motor cycles.

The need for such a simple noise test has been emphasised at some time or other by almost everybody involved in the control of noise from motor vehicles. The requirement for such a test was one of the conclusions drawn by the House of Lords Select Committee in their 1985 report on Motor Cycle Noise, and was a point raised by many of the bodies, including the NSCA and BMF, who gave evidence to that Committee. However, there has to date been no attempt to define such a test.

3. The Derby Experiment

During the early summer of 1986, Derbyshire County Council's Public Protection Committee received a number of complaints from local representatives about motor cycle noise, and agreed that Derbyshire Constabulary be asked to investigate these complaints and to take what action they could to resolve the matter.

The Police, not having the facilities to carry out noise measurements themselves, approached the Environmental Health Departments of the County's constituent authorities and asked for assistance, and it was subsequently arranged that officers of those departments would measure noise levels during the Constabulary's annual Motor Cycle Safety Campaign. The results of these measurements were the subject of a paper presented at the Society's 53rd Annual Conference in Blackpool in 1986.

Early in 1987, Officers of Derby City Council's Environmental Services Department were invited to participate again in the Constabulary's annual Motor Cycle Safety Campaign. Similar invitations were made to the other Derbyshire Local Authorities, but due to administrative problems, these never came to fruition.

It was arranged that the exercise in Derby would be conducted during the latter half of July, 1987, and that it would be run at five sites in the City.

The format of the exercise was simple. Motor cyclists would be stopped at random on roads near the test sites by Police Motor Cycle Patrol Officers, and would be invited to

attend the test sites where their machines would be examined by a Police vehicle examiner and where officers of the Council's Environmental Services Department would measure the noise levels produced by the motor cycles.

It was agreed from the outset that as the success of this exercise would depend solely upon the co-operation of the motor cyclists who participated in it, no action would be taken by the Police in respect of any vehicle defects discovered during the course of the exercise.

3.1 Measurement Procedures

The nature of the Police Motor Cycle Safety Campaign placed severe limitations upon the type of noise measurement which could be made. The use of road side test sites and the fact that all participants were 'volunteers' meant that the method employed would have to be quick and thereby simple, and to be capable of being used in areas with moderately high background noise levels. It was thought likely that the level of noise produced by a motor cycle would depend principally upon the size of the engine and the type and condition of the silencers with which it was fitted and consequently a test method was chosen that would examine the relationship between these basic parameters.

The method chosen was essentially a very crude approximation of the static test described in EEC/1015/78 and ISO 1530. The machine was placed on its stand and with the gearbox in neutral, the maximum 'A' weighted noise levels produced, while the engine was revved at approximately half throttle or half maximum revs, were measured at a distance of one half metre from the exhaust outlet and at an angle of 45 degrees to the exhaust axis (Figure 2). The half throttle or half maximum revs condition was used because it was reasoned that with the machine in neutral this would approximate to the maximum engine speed likely to be achieved in road use and it was at these higher engine speeds where the difference between a good and a bad silencer became most noticeable. Initially it was envisaged that the half throttle setting would be held constant during the measurement period, but as this, especially with the more powerful machines, tended to cause

over-revving, the test technique was modified and measurements were made with a rising throttle that was closed when the appropriate engine speed had been achieved.

With multi-cylinder machines fitted with left and right hand exhaust systems, measurements were made at the appropriate position on either side of the vehicle. Silencers were classified as either Standard (OE) or Non Standard, and their visible condition as Good, Average or Poor.

One hundred and ten machines were examined in the course of the Derby experiment. These ranged in capacity from 50 to 1100cc and in age from 30 years to a few months old. The silencers fitted to these machines varied from virtually new through the full range of standard and non-standard replacements to essentially unsilenced and straight through systems, and the condition of the silencers from perfect to very poor.

3.2 Results

The information obtained from the Derby test comprised details of the make and engine capacity, silencer type and condition and the noise levels for each of the machines examined.

Initially this data was displayed as shown in Figure 3 as a plot of noise level against engine capacity, but as will be seen from this figure, there was apparently no simple relationship between noise level and engine capacity. The next step was to separate from the data all those machines fitted with standard silencers in apparently good condition and to display this data as a plot of noise level against engine capacity (Figure 4). From this figure it will be seen that only 5% of those machines fitted with standard silencers in good condition produced levels of noise that exceeded an arbitrary straight line drawn through the two points 100cc/94 dB(A) and 1000cc/98 dB(A).

To complete the picture a similar exercise was conducted for that portion of the sample comprised of motor cycles fitted with non-standard silencers and with standard silencers in poor condition. This data is shown in Figure 5, from which

it will be seen that 80% of the machines fitted with non-standard silencers produced levels of noise that exceeded the arbitrary 100cc/94 dB(A) - 1000cc/98 dB(A) line.

The results of the Derby experiment showed, as might be reasonably expected, that motor cycles fitted with standard exhaust systems produced less noise than those fitted with non-standard systems or standard systems in poor condition. However, the very distinct split between the two classes of exhaust systems, seemed to indicate that a simple static test could be used with an acceptable level of confidence, to distinguish between 'noisy' and 'acceptable' machines.

The results of the Derby experiment were discussed by the Noise Committee of the National Society for Clean Air and as it was considered that the simple static test might form the basis of an effective method of control, the Society agreed to fund a further investigation aimed at validating the technique.

4. BMF/NSCA Motor Cycle Noise Exercise

Any realistic investigation of noise levels from in-use motor cycles requires access to a large sample of such machines. A sample of this nature is not normally available, so the NSCA took the radical step of asking the British Motor Cyclists Federation for permission to send a team to the Federation's Annual Rally at Peterborough, said to be the largest gathering of motor cyclists in Europe. The BMF, who are themselves anxious to promote the respectable image of motor cycling and to demonstrate that the vast majority of their members are responsible citizens who do not ride noisy machines, agreed to the Society's request. In fact such was the enthusiasm of the Federation's response that it was decided to conduct the tests as a joint BMF/NSCA exercise.

The NSCA team at the Rally was composed of members of the Society's Noise Committee and was supported with personnel, instruments and equipment by Castle Associates and Lucas CEL and by Peterborough City Council.

The measurement technique used at the Rally was essentially

that employed in the earlier tests in Derby. Engine speed was set either by selecting a half throttle position or by using the machine's tachometer to select the engine speed equivalent to half maximum revs. In each case measurements were made on rising throttle and silencers were classified according to condition and whether they were standard (OE), British Standard marked replacements (BS), or non-standard units.

During the course of the two day rally the team made noise measurements on 316 machines of widely varying age, size and condition.

4.1 Results

The data obtained at the BMF Rally was tabulated in the same way as for the Derby experiments, and from the initial examination of this data it could be seen that the repeatability of the test technique for numbers of machines of the same make and model was within acceptable limits.

The results of the Derby experiment (see Figures 3, 4 and 5) were displayed as a straightforward plot of noise level against engine capacity. This method of illustrating the difference between a standard and non-standard exhaust system, however, becomes unwieldy when there are large numbers of data points to be examined, and as the measurements made on the 110 motor cycles at Derby and the 316 at Peterborough contributes in total in excess of 600 data points, it was necessary to utilise a different technique to display the information.

Consequently the data was sorted into three engine capacity groups, these being less than 400cc, 400-800 cc, and greater than 800cc, and the noise levels of the machines in each of these groups were sorted into class intervals of 3 dB(A). Cumulative percentage frequency curves of noise levels were then plotted for the standard and non-standard exhaust systems for each of the three capacity classes detailed above. This data is contained in figures 6, 7 and 8.

Once again as might be expected, the data displayed in figures 6, 7 and 8 shows that standard silencers in good

condition are considerably quieter than non-standard silencers or standard silencers in poor condition. In fact, as will be seen from these figures, the difference between standard and non-standard silencers in each of the three engine capacity classes is so great that any small variation in noise level due to engine speed or throttle setting is really insignificant. Also from these figures it will be apparent that the variation in noise level within the sample for motor cycles with standard silencers is much less than for motor cycles with non-standard silencers or standard silencers in poor condition.

It will also be seen from these three figures that the largest variation in noise level occurs within the top 10% of each sample and it is probably a valid assumption that those silencers composing the top 10% of the standard sample were either in 'poor condition' and not recognised as such, or had been modified or altered in some way not apparent to the testers. There therefore seems to be justification in taking as a maximum for each of these capacity classes the noise levels exceeded by either 5 or 10% of the standard samples, and in Figure 9 these values have been plotted in the form of a histogram.

The noise levels exceeded by 5 and 10% of the standard samples have also been applied to the non-standard silencer data and the histogram in Figure 10 shows the percentage of those machines in the non-standard sample which exceed the values exceeded by 5 and 10% of the standard sample. This data is also displayed in Table 1.

The figures shown in Table 1 are higher than the noise levels specified in the Construction and Use Regulations 1986, but this is because the figures in the Construction and Use Regulations refer to a drive-by test whilst those in Table 1 refer to the higher engine revs used in the static test. There is unfortunately no apparent relationship between the two sets of figures.

From Table 1 and Figures 9 and 10 it will be seen that a large percentage of motor cycles with non-standard silencers exceed the noise levels that are exceeded by only 5 and 10% of equivalent machines with standard silencers. It is also of note that the noise level exceeded by 5% of all motor cycles

fitted with standard silencers, varies between the three capacity classes by only 1 dB(A). Thus there would be some justification in selecting the figure of 100 dB(A) as the maximum permissible noise level for any motor cycle no matter what its capacity.

5. Proposals

The main thrust of the Department of Transport's programme to control motor cycle noise is aimed at eliminating the supply of non-standard and hence ineffective silencers. However, even if everything goes according to plan, it will be several years before the effects of this programme become noticeable, and in the meantime and thereafter there is and still will be a need to ensure that motor cycles in road use do not produce excessive noise levels. This objective is recognised by Local Authorities, the Police, the British Motor Cyclists Federation, and ordinary citizens, and yet it will be almost impossible to achieve without the noise testing of in-use motor cycles.

The work carried out by Derby City Council and the National Society for Clean Air has demonstrated that the difference in the noise levels produced by motor cycles silenced to the maker's specifications and those fitted with non-standard or damaged silencers is so significant that a simple static test can be used to distinguish accurately between the two.

The introduction of such a test would not even require the provision of new legislation for, as representatives of the BMF and the Police have both pointed out, tests of this nature could be conducted and if necessary prosecutions taken, under the existing provisions of Regulation 97 of the Construction and Use Regulations 1986 which prohibits the operation of a motor vehicle in a manner likely to cause excessive noise, or indeed under Regulation 54(3) which requires that a silencer shall be maintained in good and efficient working order and not altered so as to increase the noise made by the escape of the exhaust gases.

Acting under these Regulations, Police Officers would be able to conduct roadside tests of the type outlined in this

paper, and the riders of those machines that were found to be excessively noisy could be served with Vehicle Defect Rectification tickets and required to present the repaired machine for inspection within a certain time period. Similar tests could also be applied at M.O.T. testing stations on the occasion of the machine's annual examination.

This approach to the problem of motor cycle noise would be cheap and effective, but most importantly, would discriminate not against motor cyclists in general, but only against that irresponsible minority who insist on causing excessive noise and thereby bring their fellows into disrepute.

The same philosophy and test technique could eventually be applied to other sectors of road traffic and in particular, to private cars and heavy goods vehicles. In the case of the latter, the question of engine speed would be much easier to resolve, as diesel engines could be tested at the maximum engine speed allowed by the engine governor. Once again, a large sample of vehicles would be needed to establish the norm, but thereafter simple tests could be applied either at the road side or at the MOT testing stations, and it would seem reasonable to expect that the long term effect of such a programme would be the elimination of much 'unnecessary' traffic noise.

6. Conclusions

The work carried out by Derby City Council and the National Society for Clean Air has shown that a static noise test can be used to distinguish between a 'noisy' motor cycle and one silenced to acceptable standards.

The data contained within this report shows that 95% of all motor cycles with standard silencers in good condition produce levels of noise that are less than 100 dB(A) when measured in accordance with the test procedures described. Furthermore it has been found that a very large percentage of motor cycles fitted with non-standard exhaust systems exceed the 100 dB(A) level.

It would be possible by use of the Construction and Use Regulations 1986 to enforce the 100 dB(A) level as the

maximum permitted for any road motor cycle. There are indications from both the police and BMF that they would support the introduction of this standard. Such a move would effectively eliminate the large proportion of motor cycles fitted with non-standard silencers and it is these machines which cause annoyance and offence to the public at large.

It is therefore strongly recommended that a test of this nature be adopted and enforced by both the Department of Transport and Police authorities in respect of motor cycle noise, and that work be initiated to apply a similar test technique to other sectors of road traffic.

Acknowledgements

The author wishes to acknowledge the advice and assistance given to him by: The British Motor Cyclists Federation; Castle Associates Ltd.;Derby City Council; Derbyshire Constabulary; Lucas CEL Instruments Ltd.; The National Society for Clean Air and fellow members of the Society's Noise Committee; Peterborough City Council; Those motorcyclists who participated in the measurement programme both in Derby and at the BMF Rally.

	ENGINE CAPACITY GROUP		
	< 400cc	400 - 800 cc	> 800cc
Noise Level Exceeded by 10% of Standard Sample	96.5dB(A)	97dB(A)	99dB(A)
Percentage of Non-Standard Sample Exceeding this Noise Level	59%	88%	80%
Noise Level Exceeded by 5% of Standard Sample	99dB(A)	99.5dB(A)	100dB(A)
Percentage of Non-standard Sample Exceeding this Noise Level	38%	70%	76%

Table 1 - Comparison of Percentages for Motor Cycles with Standard and Non-Standard Exhaust/Silencer Systems.

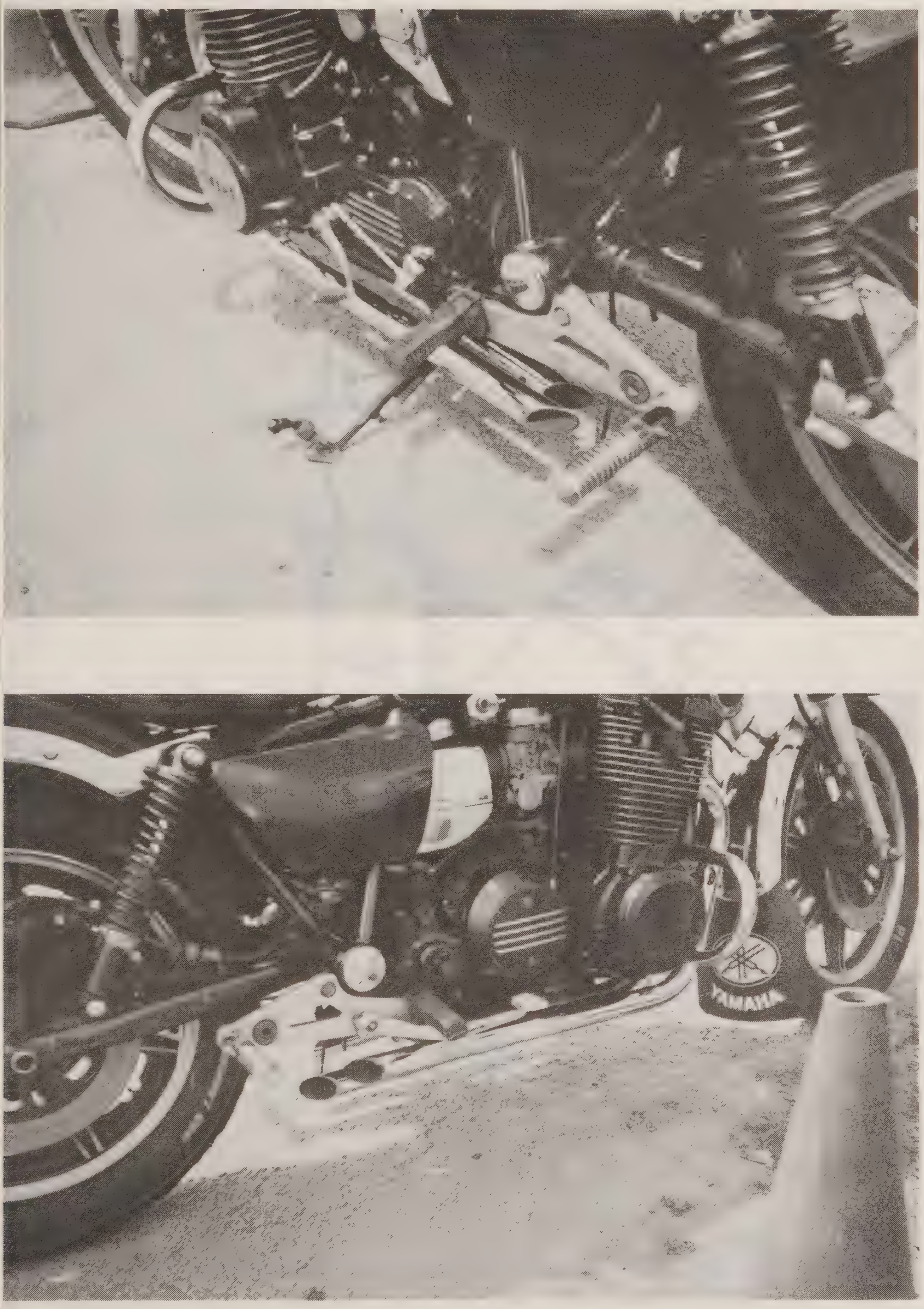

FIGURE 1 Example of Non-Standard Exhaust System

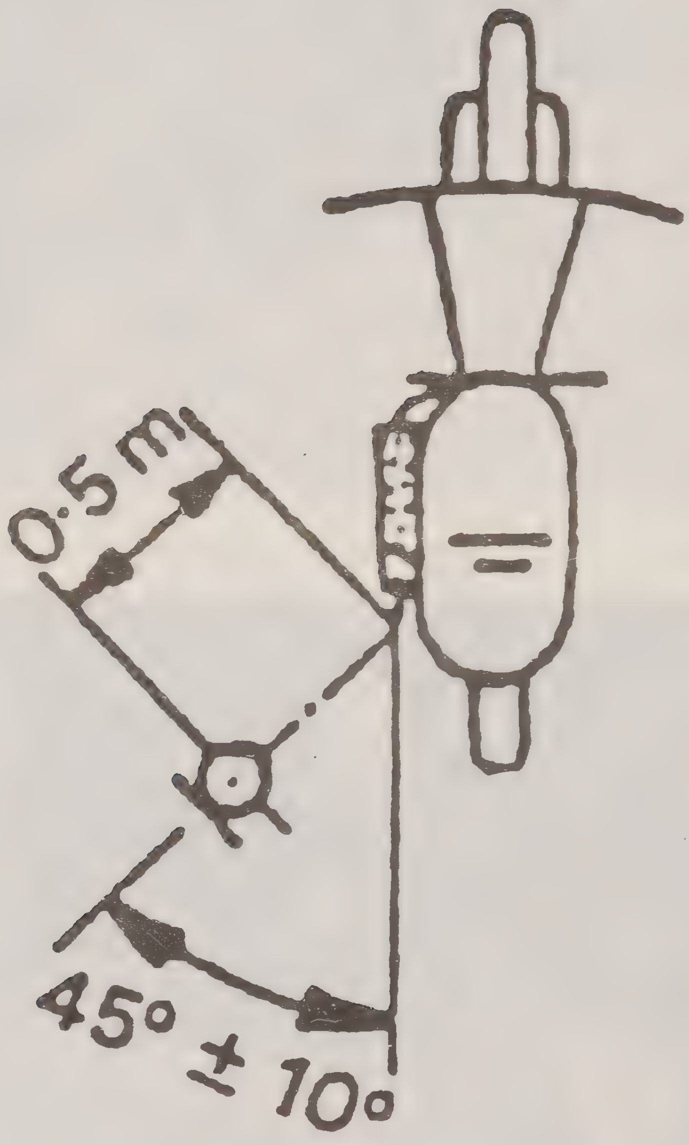

FIGURE 2 Microphone Position For Static Noise Measurement

Figure 3 SPL vs Capacity. All Machines

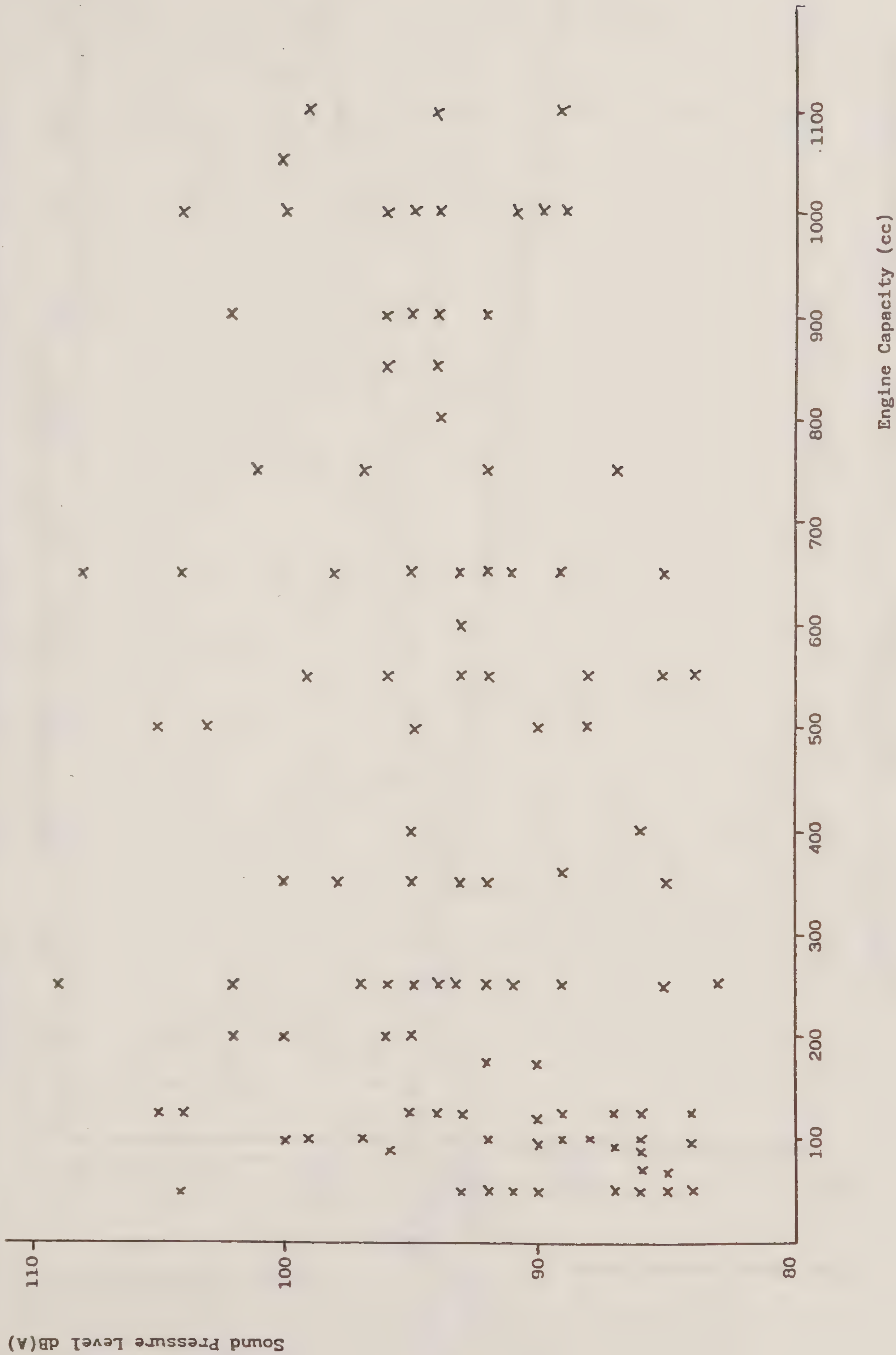

Figure 4 SPL vs Capacity. All Machines with standard Silencers in Good Condition.

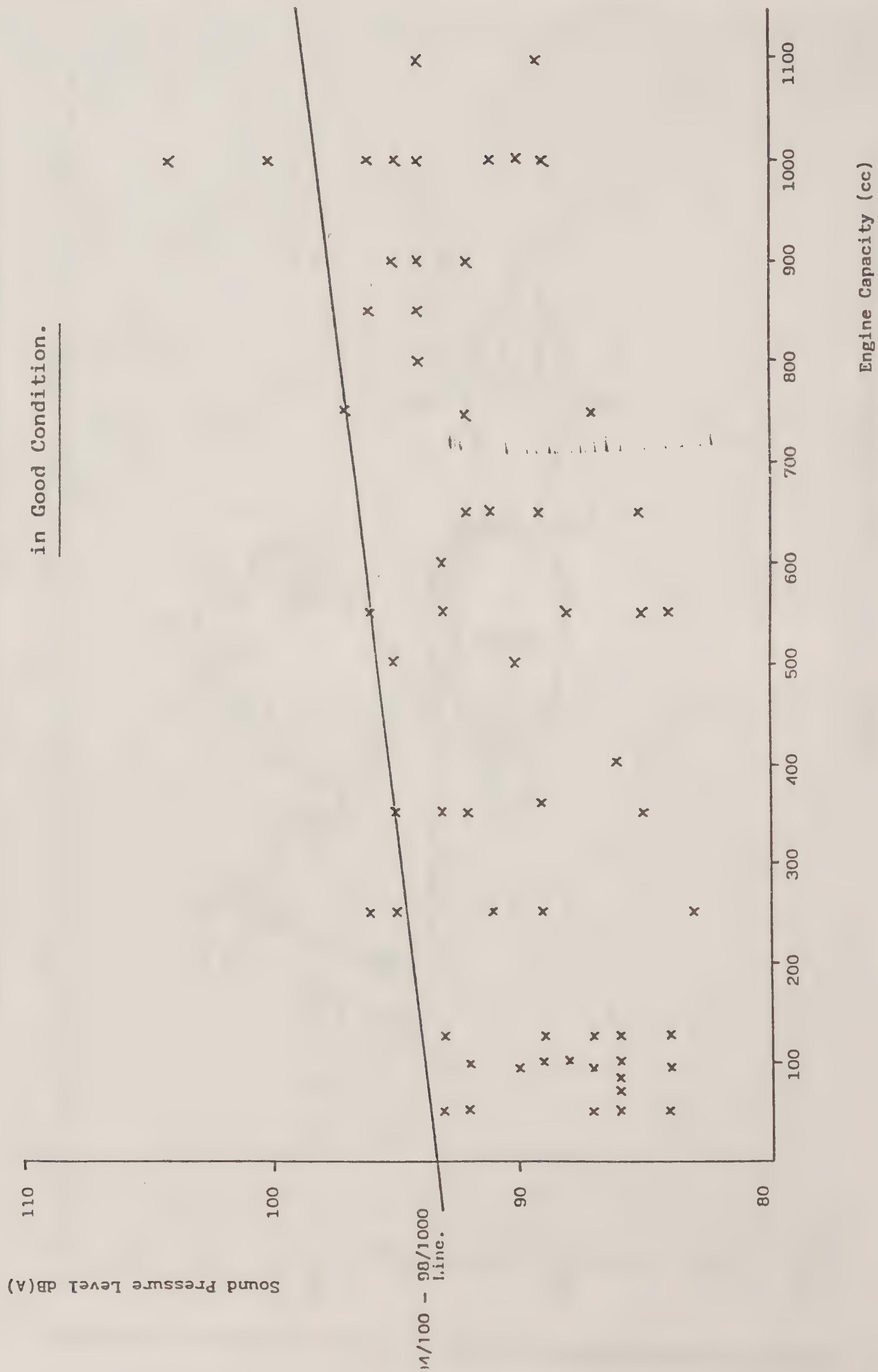

Figure 5. SPL vs Capacity. All Machir. , with Non-Standard Silencers or Standard Silencers in Poor Condition.

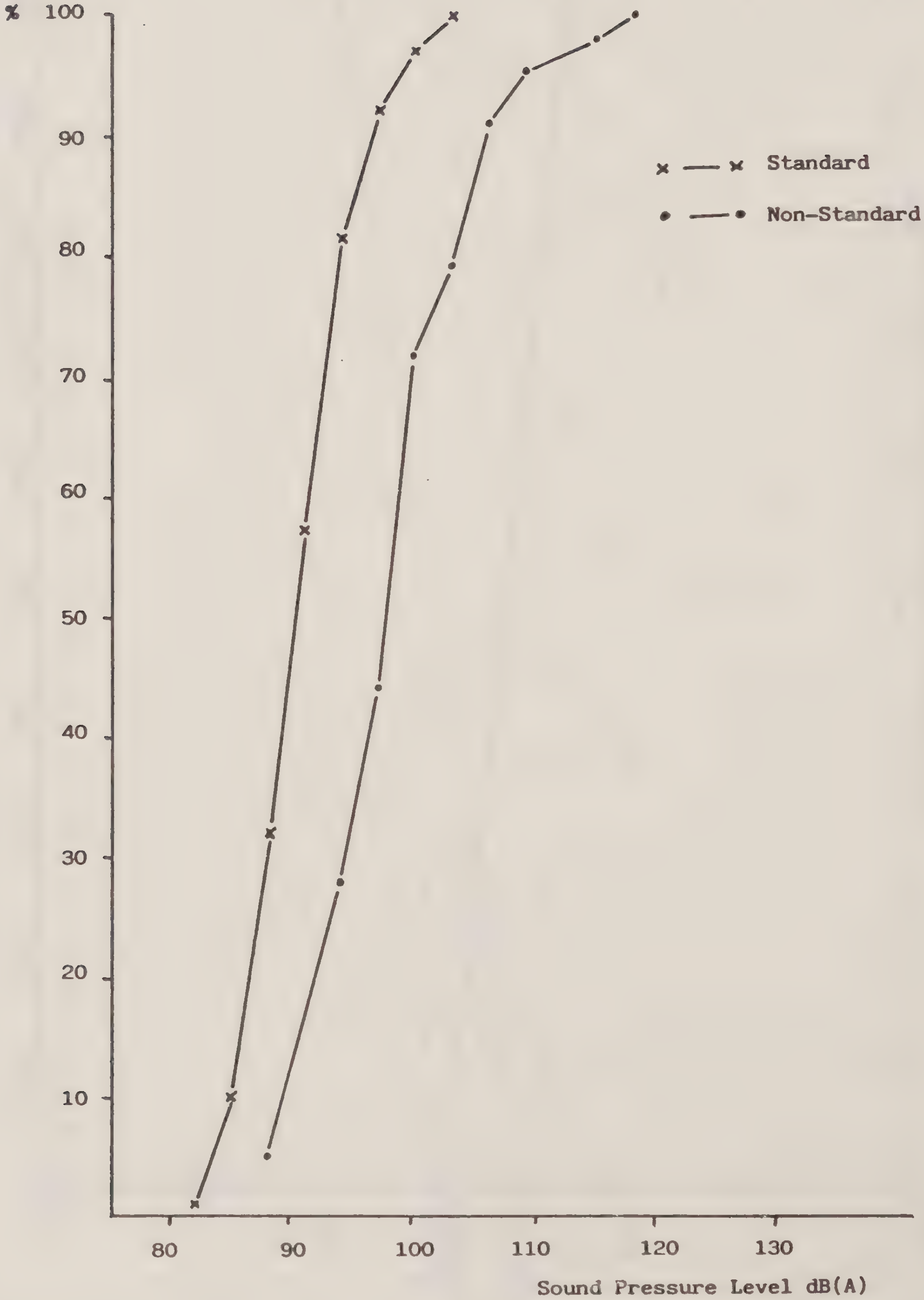

FIGURE 6

Comparison of Noise Levels for Motor Cycles with Standard and Non-Standard Silencers with Engine Capacity Less than 400cc

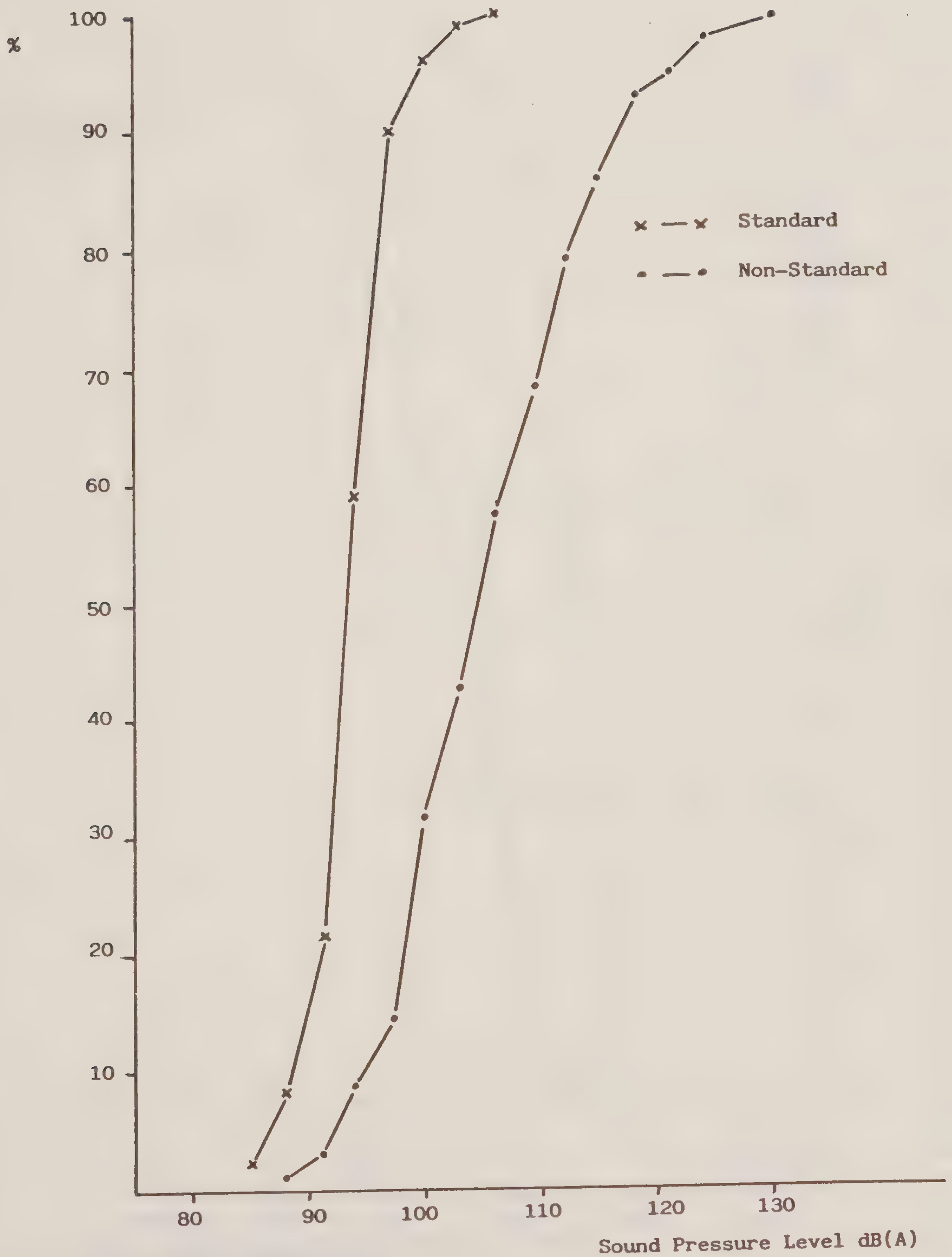

FIGURE 7

Comparison of Noise Levels for Motor Cycles with Standard and Non-Standard Silencers with Engine Capacity 400-800cc

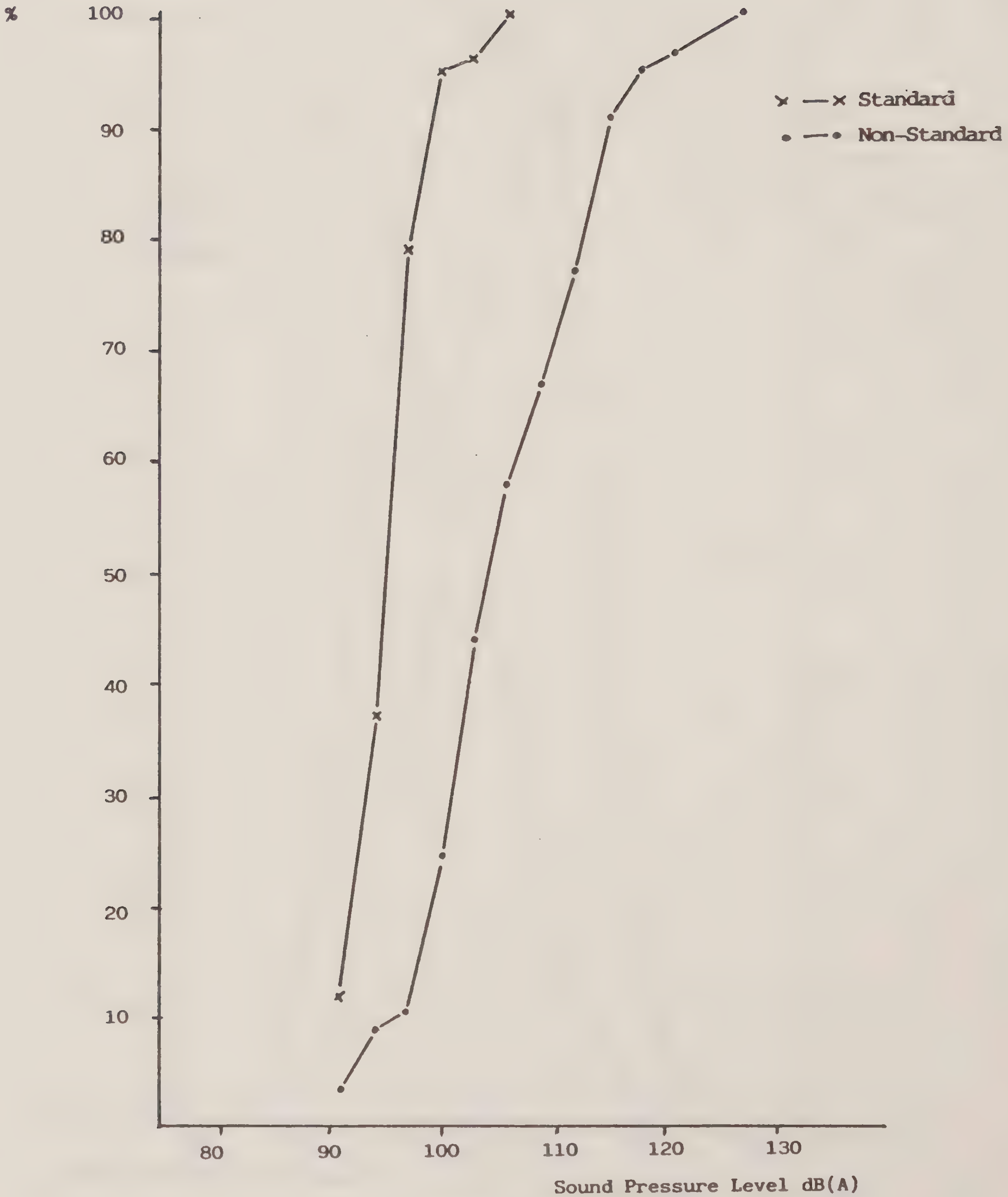

FIGURE 8

Comparison of Noise Levels for Motor Cycles with Standard and Non-Standard Silencers with Engine Capacity Greater than 800cc

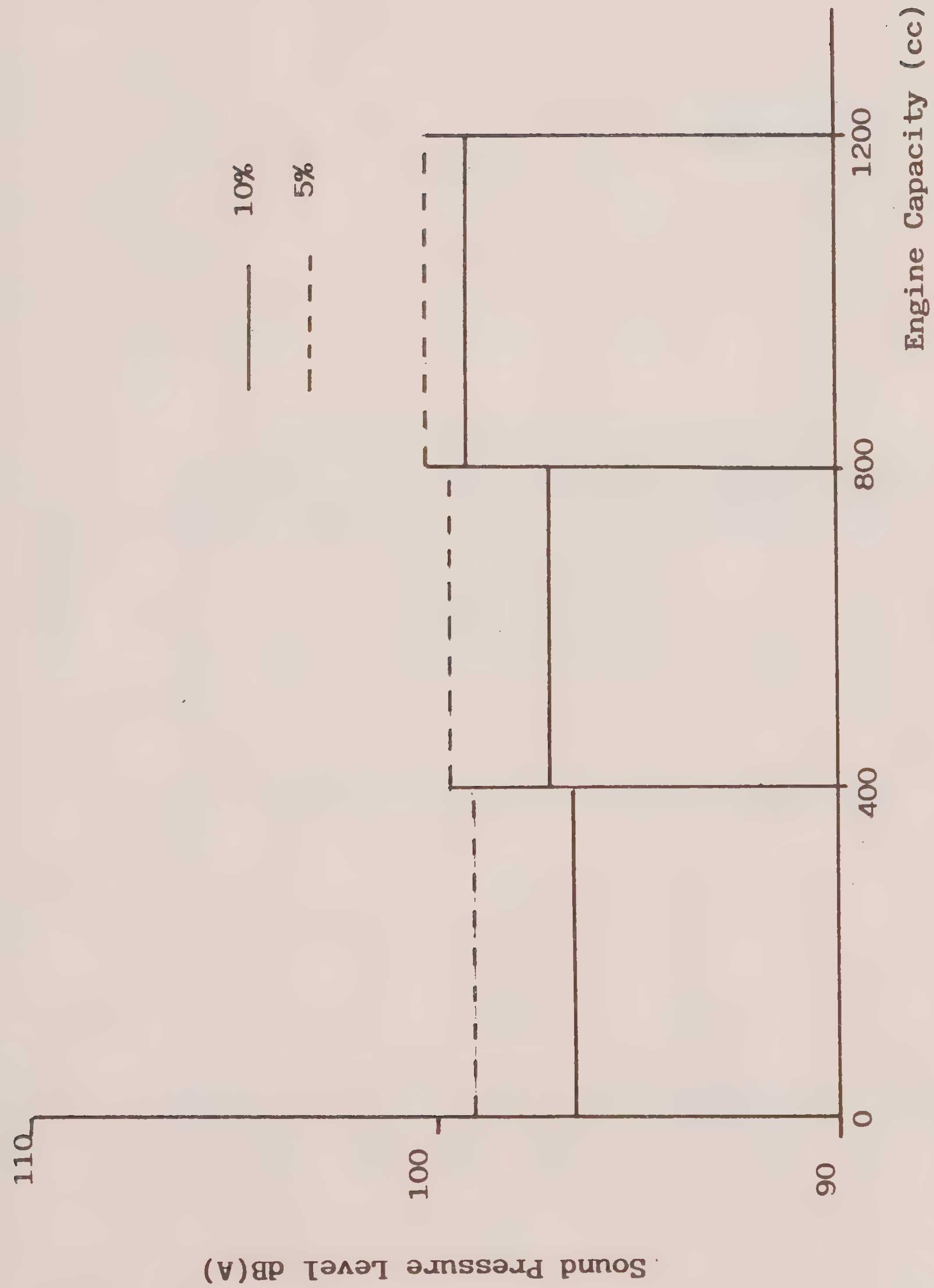

FIGURE 9

Noise Levels Exceeded by 5% and 10% of Motor Cycles with Standard Exhaust Systems

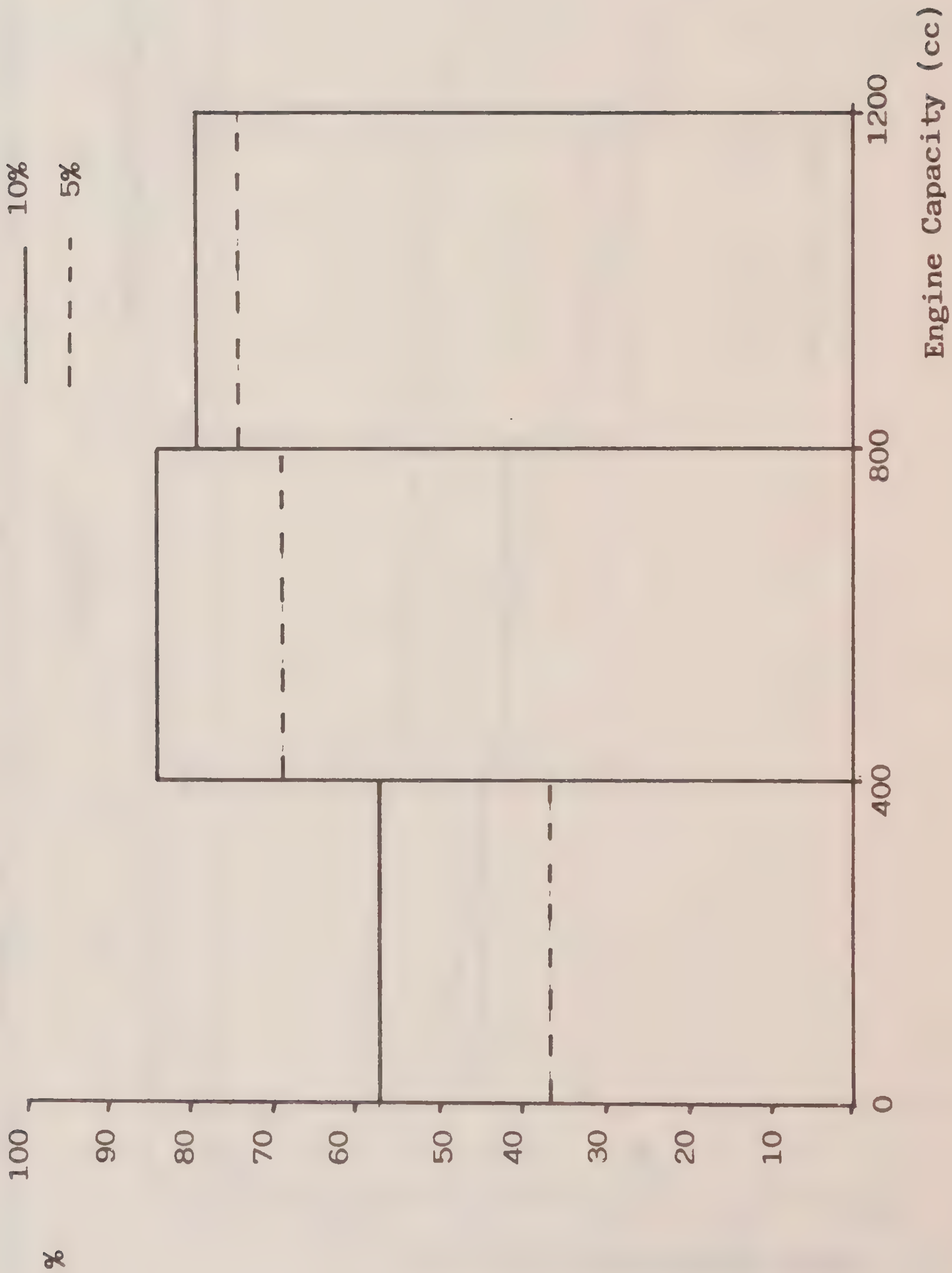

FIGURE 10

Percentage of Motor Cycles with Non-Standard Exhaust Systems That Exceed the Noise Levels Defined in Figure 9

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SESSION 7

CIVIL NUCLEAR POWER
HOW SAFE IS SAFE ENOUGH?

Chairman

D R Cope

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55th ANNUAL CONFERENCE
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CIVIL NUCLEAR POWER
HOW SAFE IS SAFE ENOUGH?

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Introduction

I have been asked to talk from a scientific point of view. Professor Kasperson will be talking about the 'social point of view'.

My interest is that of the administrative head of a regulatory authority, which includes scientists, inspectors, and a wide range of technologists capable of understanding most industrial processes and structures. My organisation exists because society sees a need to control industrial risk, and the social and scientific points of view are equally important to us. We are there to respond to society's needs, and sometimes indeed to social perceptions which from a purely scientific point of view might seem quite wrong-headed.

I do not suppose that anyone would expect us to take our regulatory decisions on nuclear power or anything else without seeking to establish what degree of risk is involved, and deciding what is acceptable to us. My talk concerns how far one can make estimates in these matters; where judgement comes in, and what kind of judgement we are talking about. I shall in addition permit myself some wider speculations as to the nature of the frontier between scientific and public opinion.

The wish of the public in relation to major industrial activity would probably be 'make sure there is no risk'. It is not perfectly clear what would be meant by this. People understand very well that if they are active in any way, they are taking risks. Perhaps what might be particularly objected to in major industrial hazards is their potentially catastrophic effect, which could injure individuals or their families whatever precautions they take. People feel keenly that they as individuals did not, as it were, ask for the risk, though we all benefit from it. Perhaps they are also influenced by the fact that the industrial record in this country is reasonably good: high expectations breed still higher ones. Whatever the explanation, any study of the risk estimates implicit in the precautions that are actually undertaken to reduce major industrial risks, will show that

we do implicitly demand that they be reduced so that the risks to individuals are much lower than those we accept voluntarily. I mean, by factors between 10 and 100 lower, depending on the nature of the risk and the dread in which it is held.

We immediately see that the major judgement is a political and not a scientific one. It is, whether a given risk is tolerable having regard to the social benefits of running it. Having said that, we find ourselves asking questions which can only be answered with the aid of science and experience. What is the degree of risk we are being asked to run? How should that be expressed and compared? - obviously in relation to other risks with which we are more familiar, since otherwise there is no way our minds can get hold of the question. Then, if we decide to tolerate the risk - can it be reduced further and at what cost?

Let me clear up a possible misunderstanding. A framework which begins with the question, what degrees of risk do we actually tolerate need not be a device for sanctifying the existing order of things. Just because (say) the Titanic ran into an iceberg, one must not say 'liners run into icebergs every now and again, perhaps every 50 or 100 years; society seems to live with this; worse things happen (though not I think at sea!) and the level of Titanic disasters that we will tolerate is therefore about once in 50 or 100 years'! The right point of view must surely be: 'the Titanic ran into an iceberg. Do shipping companies still want to sail liners in these waters? With experience to date we seem prepared to tolerate a certain number of such disasters per century, but what now can be done to reduce the risk further? At what point does the consequential cost of the necessary measures cease to be worth taking - ie, when is the residual benefit from each improvement exceeded by the cost?' At this point, we begin to set new standards, and if liners cannot meet them, they should not be allowed to sail. The residual risk must be regarded as part of the price paid by society for the convenience of travelling.

Now the importance of setting a framework in this way is that it produces a set of questions that science, experience and engineering can address. They cannot tell us what in

the last resort is tolerable, though they can help to put numbers on the social judgements we make. And they cannot necessarily be very exact even when addressing the second order questions about the cost and benefit of each incremental piece of risk reduction that might be taken up eg in the course of design. But they do help to set maxima and minima, and assist in guiding judgement. That is, if we let them, and if we do not insist on unattainable provisions or try to pretend that we can get into a zero risk position.

This is, of course, a pragmatic rather than idealistic approach. It has the merit of facing reality. It is as valid an approach for nuclear power as for any other activity: though within that broad framework, various factors such as public concern may call for us to be stricter with nuclear risks than with others.

DO WE NEED NUCLEAR POWER? SHOULD WE NOT ADOPT SAFER ALTERNATIVES?

It is therefore fair to ask first whether we should have nuclear power at all. This is not a question that we as a regulatory body can, or should seek to answer. It is not for us to propose nuclear power; it is for others to come to us saying that they want to construct a reactor. Our function is to examine what are the risks involved, as estimated by experts, and to consider whether what is proposed can be improved and to what extent it is worth doing so. But we can help society to make the fundamental decisions by publishing our own suggestions as to a standard of tolerability at least for new stations, based on our assessment techniques; and this we did when we recently published our document on the Tolerability of Risks from Nuclear Power Stations. We can also, if anyone wishes to listen, and they need not, set out the geometry for a social decision on nuclear power. This must presumably include some of the following considerations.

It is obviously necessary to consider the risks attending to all forms of generating electricity, and to do so for the whole fuel cycle. The normal conventional sources of electricity (coal and oil) each taken together with the whole

of its relevant fuel cycle, from extraction of the fuel, to eventual disposal of waste, seem to be on most counts, and probably overall, more risky than nuclear so far as ascertained and measurable risk is concerned, though this ignores the less readily quantifiable issues connected with societal risk of catastrophe, and of course, the risks are to different sets of people.

There are several reasons for the overall riskiness of non-nuclear sources. The sheer bulk of fuel needed for coal or an oil station is very much greater than that of a nuclear station (6 or 7 million tons a year for a really big station, instead of perhaps 50,000 tons of ore). To obtain the fossil fuel involves extraction risks, and transport risks too, particularly for coal. Residual fuel oil is prepared - as a kind of by-product - from the refining process which itself presents some quite substantial kinds of societal risk. It is a matter of judgement, perhaps even disagreement, what proportion of that risk should be assigned to the fuel oil but it is not zero. The coal cycle does not present the possibility of very large scale disaster that can be found in the nuclear and oil cycles; but other risks in extraction, transport and combustion, could on average lead to more injuries and diseases. Combustion of coal or oil gives rise to air pollution which at current levels may or may not have some residual health effect upon the population - this itself is disputed. We also have to reckon the societal hazard, which may be very large indeed, of ecological and climatic harm via the greenhouse effect, which nuclear power does not appear to share.

There are, too, substantial dangers involved in the so called alternative energy sources, which may appear on the face of them to be risk free. There is something inherently attractive about a dam, a barrage, or a windmill (I am not suggesting solar power sources in Llandudno in October).

To be useful on a national scale however, these 'alternative' sources have to be either very big, or very widespread; and arrays of large dams, barrages, or windmills produce risks in construction, and operation. The largest industrial accident in Western Europe since the war was the failure of a dam and I am told that the Chief Safety Inspector in Holland was

actually killed a few years ago by a windmill. The 'alternative sources' can also act as 'nuisances' which will not always appeal to those who live, or used to live, nearby. Installations required to generate even small quantities of electricity by such means are very large and obstructive structures.

Against these factors of course, the nuclear power option manifestly includes some risk of very large accidents, and involves the disposal and to some extent dispersal of radioactive waste. These facts and dangers are so well known - perhaps better known than the others - that I need not dwell on them. They are very clearly set out in the Tolerability of Risk document. It really is not the duty of a regulator as I have said to make final judgements about these matters. But a regulator is in a position, because he is going to be called in whatever solution is adopted, to make judgements of a sort, and to communicate the basis of these judgements to the public. So a regulator is in a position to see the whole range of possibilities, and ought perhaps to share his perspective widely.

THE JUDGEMENTAL ELEMENT IN DECISIONS

We have seen that the risk regulator has to understand and promote scientific estimates of risk - often imprecise and sometimes uncertain as these may be. The decision maker, whether this is the Minister in Parliament as to what is tolerable, or the regulator as to how much more safety he ought to ask for, must have a fair eye for political reality, and this includes a sensitivity to public opinion.

Why is this type of decision so essentially political? Because it involves the redistribution of cost and risk. Everybody may receive the benefit of a decision to take an industrial risk, but one group may bear the risk - ie generally those nearest to it. And indeed, as I have pointed out, questions arise as to which risk is to be preferred, or whether the burden should be borne now or (as sometimes in the case of radiation) by future generations. All large redistributive decisions of this kind are in their nature social and political.

I have every reason to hope that scientists will agree with me here: the Royal Society Study Group on Risk Assessment said that Government decisions on risk should be 'essentially political although informed scientifically'.

Frequently in this talk I have referred to the word 'tolerability'. In this context, the word takes its origin in Sir Frank Layfield's report on the Sizewell Inquiry, which invites HSE to formulate guidelines on the tolerable levels of individual and social risk to workers and the public from nuclear power stations. This was the purpose of our tolerability paper. In doing this, Sir Frank introduced this word into the risk vocabulary. 'Tolerability' which (with its political and even emotive overtones), is by no means the same thing as the word 'acceptability' used up to now in the literature, and it is necessary to define the bearing of the two upon each other.

The attached diagram (Figure 4 of the Tolerability Paper) sets out the geometry of risk regulation as we see it, not just for the nuclear but for all forms of risk. We could, incidentally, have drawn it without the benefit of any new concept of tolerability since we have always taken the view that the first question in respect of any risk is whether to take it or not.

The geometry is as follows. There is a level of risk which is intolerable. What this level is, is a matter for political decision which is based, as all such decisions are, on contemporary realities. Below that as I said when I gave the illustration relating to the Titanic, an activity is tolerated if it bring benefits, but the risk should be reduced as low as is reasonably practicable (ALARP). In doing this it is likely to become progressively more acceptable, to progressively increasing numbers of people. At quite low levels it becomes generally acceptable except to minorities. At some point it becomes negligible in the sense that, apart from taking standard precautions we can wholly ignore it,

Just below the top level where the risk would otherwise be intolerable it is appropriate to impose a considerably stricter level of control than might be suggested by a somewhat stark balancing of the cost of accidents with the costs of

their control. Below this high level, an economic balance between successive increments of cost and risk becomes progressively more relevant in determining the level of control we should insist upon. At the generally acceptable level, we cease to trouble ourselves with any further calculation or any additional precaution. Since in the majority of cases the public or workers have long been in this relatively relaxed position, it is usually the regulator who takes the decision to cease to worry.

THE ROLE AND NATURE OF THE SCIENTIFIC EVIDENCE

At the most sophisticated level, and certainly for nuclear power, the scientific contribution principally consists of a quantitative risk assessment, which can, in the case of a discrete complex of plant such as a nuclear power station, take the form of a comprehensive framework within which risk figures can be attached to most or all of the mechanical pathways to plant failure. I need not in this audience probably, describe the techniques involved, which include the identification of failure sequences, the application of plant reliability data and the building in of layers of protection including alternative or back-up systems. But I do need to say that, elaborate as such framework can be, the risk estimates within it are incapable of precision. Plant reliability data must at many points be reinforced by engineering judgement - not certainly so crude as that of the architect Lutyens when he said that he 'did not know anything about engineering but he could say that a 14 inch beam would hold anything he could put on it', but a process where calculation and experience begin to merge.

Nor can a quantitative risk assessment cover every factor. Different forms of QRA exist, some of which are far from comprehensive even as regards plant failure. Thus in a chemical plant, QRA may deal only with the parts where chemical reactions are planned to take place, rather than with the whole system including for example the pipework. QRA cannot fully take account of human failure, though it must be borne in mind that human failure will generally only translate into serious accidents if either it results in plant failure, which will then bring protective systems into play, or

specifically if the plant fails to shut down or is prevented from shutting down when a failure sequence begins. So to that extent human failure is taken into account in the QRA. What cannot be taken into account so easily is human failure of the kind that occurred at Chernobyl, where the operators too easily found means to remove the protections provided by the designer, and they did this on a plant which was known to be inherently unstable in the operational mode in which they found themselves.

There are examples of human failure not wholly removed from this in our own industrial history, though not I am glad to say, in relation to nuclear plant. I believe for example that a madman employed as a railway signaller was discovered to have systematically removed protective systems with an intention to derail a train. More frequently, we have had human failure of the kind that occurred at Flixborough or indeed at the BP plant in Grangemouth last year, in both of which cases modifications destroyed the safety integrity of plant and of instrumentation in ways that only became apparent in unusual circumstances.

So it can happen; but it can be reduced to a remote chance if the attention paid to safety is geared to a high level, if 'fail safe' is built into all procedures and if the removal of protective systems is made so difficult that an attempt cannot fail to be noticed. That of course is the business of the management, and of the regulator.

Acknowledging these deficiencies in QRA, it still brings major benefits. The first is in providing a framework within which as many as possible of the relevant questions can be asked, and the answers examined. The second is in permitting some approach to an overall estimate of risk - at least within an order of magnitude, and bringing us near to a point at which safety goals can be defined. And the third is, to enable the risks associated with different parts of the plant to be balanced, since there is little point in driving down most risks to a million to one, leaving open one possibility that is a hundred or ten to one.

QRA can also help us, within the limits I have explained, to communicate some sense of quantity in making the decision

on tolerabiliy. In the tolerability paper, we used as our comparator decisions actually taken as to the degree of societal risk to be accepted at Canvey Island and the Thames Barrier - also situations with a potential of killing perhaps thousands of people. In these two cases, of course, society has little choice but to accept a major societal risk. In practice, our society has accepted in these cases risks of between 1 in 1000 and 1 in 5000 per annum of a very large accident that could kill thousands of people. Based on this we suggested an upper level of tolerable risk for pressurised water reactors, that was considerably stricter than what society had accepted for the other two risks and moreover, we made it include delayed as well as immediate deaths, and insisted on adding up the risks from a whole programme of reactors. In all this, there is an induction from contemporary conditions and a decision, supported by scientific computation.

Too much attention should not however be given to the level of tolerability. We must aim always to do better. Great importance must be attached to the ALARP concept of driving any risk down further to what is as low as reasonably practicable. This I believe is one reason together with the improvement in technological possibilities, why our industrial safety record has progresively grown safer over the years, without bankrupting all concerned.

So much then for what the scientist, or at least the scientific method can contribute. In a word, it can increase the rationality and so the confidence of the decision process.

But there are difficulties of comprehension at the point where technical material enters the public arena. The technical discussion of risk and harm has to the layman a terrifying quality about it. At the lowest level, it produces the same consequences for peace of mind as the study of a medical dictionary. It is also difficult for the layman - and I am one myself in these matters - to grasp the rules of scientific controversy and the significance or insignificance of diagreements between experts - disagreements which can have an uncomfortable way of sloping back to questions that are really ethical rather than scientific in nature. We need sometimes to remember for example that the question, what

is harm?, and indeed the question whether to regard a million to one risk as a one in a million certainty, are not scientific but philosophical and ethical questions. The most fundamental of all moral questions is raised in the Bible passage dealing with the question whether God should destroy the wicked city which contained only one good man *. So there is ample scope for misunderstanding in any debate about risk, and scientists themselves need to have regard to the limitations of their own contribution.

I am very well aware that the Clean Air Society is not concerned only - or indeed perhaps very much - with the nuclear risk; any more indeed than I am, since the Health and Safety Executive deals with many other risks than this one. We do not deal directly with risk to the environment except in the sphere of major accident hazards, pesticides, or the release or potential release of microbiological material; but what we do has potentially a considerable trade-off with environmental harm. Indeed as I have said elsewhere, there is no technical, but only a political basis for making distinctions between regimes of protection as between whether they protect people or whether they protect the environment. To take an obvious point, connected with another very important risk, it has until recently been the practice to encourage the industrial use of chlorofluoro hydro carbons because of their relatively low toxicity. So perhaps we should take a minute or two to catechise the range of major risks to the public and to consider for a moment why it is that the civil nuclear risk has assumed so important a place among them in the public mind.

We have ourselves tried to 'rank' some of the more important hazards by the use of QRA techniques, but there is a limit to what we have so far been able to manage. If we look at the range of risk, there are first the societal risks from certain major plant. The events at Bhopal and Mexico City (and a good deal nearer home some years ago at Flixborough) show that vigilant risk control and proper land planning regimes are essential, and such regimes are of course nowadays applied.

* Genesis XVIII - ten good men, but the difference is immaterial to the argument.

Second, there are very substantial risks from the transportation and transfer of dangerous materials by road, rail and through the ports; and these risks are the more important because it is often difficult or impossible to detach them from concentrations of people.

Third, there are the possible long term effects of chemical effluent or pollutant in doses well below the control levels set by observation of known - usually short term - effect. The nuclear field is far from the only one where it has been suggested that clusters of ill-effect may be associated with particular plant; though a great deal more has to be done to disentangle the effects of the statistical methods employed from the events themselves before any of the associations so far identified can be accepted. In the meantime of course we have to keep our minds open, not knowing whether very dilute pollutants could be the cause of observed medical conditions, such as leukaemias, or whether they may be due to other causes or came about by chance.

Fourth, there are the possible ecological risks from chlorofluoro hydro carbons because of damage to the protective ozone layer.

Fifth, the Greenhouse effect; the consequential effects on world climate of increased atmospheric carbon dioxide.

One function of the Clean Air Society must, I think, be to balance and consider risks such as these and seek to ensure that the debate about them, and perhaps others which it is safe to predict will become increasingly politically and emotionally charged as we move into the shadow of the 21st Century, is conducted in terms that are as cool and well informed as possible, since the issues at stake may be very large, the mechanisms for reaching geopolitical agreement are hardly very securely established, and on the need to reach the right decisions in a well informed and not an emotional way hinges, quite possibly, the future of the human race.

From this point of view, the way the nuclear debate has been conducted offers some points of interest and perhaps some lessons to be learned. I wonder whether it would be

altogether inappropriate for a risk-regulator such as myself, to speculate a little about these. My only excuse is the importance of the issue.

We would all I think acknowledge that there is something special in nuclear development, something that has again and again touched deeply buried nerves in the body politic and brought to the surface ancient distrusts, even of science itself. Perhaps it is the fear that the operations of Dr Faustus inspired, of too much power; and of association of power specifically with the devil. I do not think it is too much to say this; I have heard it seriously, though wrongly, asserted that since plutonium is not found in nature, and therefore is not God-given, it has an inherently evil quality.

The atomic age, that is to say the era after Rutherford split the atom coincided, almost, with the rise in public esteem of science and the scientist, and the widespread acceptance of Spencerian ideas of irreversible progress based on technological advance. Nuclear physics was for so many years a queen of the physical sciences that it is perhaps largely surprising that an impression of intellectual arrogance, even the claim to moral supremacy, certainly the feeling that things were going on that were beyond the power of ordinary men to understand: it is hardly surprising that such impressions should probably mainly have clung to those who applied nuclear physics. And over and above all else, there has been the military connection; secrecy surrounding the production of the bomb and the appalling and sudden revelation of its power.

Perhaps these military origins, this secrecy, perhaps some arrogance, communicated themselves directly to the generation of those who undertook the major and, on the whole so far probably very beneficial, development of civil nuclear power. There may have been not only an assumption that the new science was unstoppable, but that no one had the right to stop or criticise it. I do not know whether this was true. But certainly I do believe that it has greatly influenced the terms on which debate has taken place. And of course, the particular characteristics of the Chernobyl event - its superficial similarity to a nuclear explosion though in fact it was a very different thing; and the

appearance it gave of human beings 'messing around with too much power' could not have been a more striking apparent confirmation of all these traits.

In retrospect, Chernobyl may one day be seen as having altered the terms of the nuclear debate decisively, by inducing a much more open discussion of the issue - due more than anything else to the openness of the Russian response and the vast and public scientific debate that followed the event. In a less spectacular way, I hope that the steps HSE have been taking in this country in the publication of the Sellafield audit, the Magnox Long Term Review documents and the recent document on the Tolerability of the Risk from Nuclear Stations will be seen as contributing to this process.

If the state of mind of the original architects of civil nuclear power was broadly as I have stated, it is hardly surprising that it should have given rise to a form of debate in which the way those opposed to nuclear power have developed their position should sometimes seem to its proponents unscrupulous or unscientific. There has certainly been a stage extended for dramatic performance, in which those opponents of nuclear power who have important things to say either of a technical kind or about regulatory method are not always distinguishable from those - including some scientists and a great many pseudo-experts, who sometimes seem simply to be seeking notoriety.

But this is perhaps no more than just to say that the debate on nuclear power has become a form of politics; and to the extent that that is what it is, the contribution that scientific and technical discussion can make, which is the subject of this paper, is very uncertain. I think that Cicero was originally the philosopher who said that nothing so strange or so little credible can be imagined, but some philosopher has been found to assert it; and the same thing would be said for scientists. The difficulty comes not when the debate is confined to scientists and philosophers but when it is being held in public, and when that area of the discussion that is speculative or concerns judgement, cannot be clearly distinguished by the spectators from the very wide area where there is agreement and number. In the real world,

there is no such thing as absolute scientific certainty, just as in the real world there is no such thing as zero risk, and the real confusion is, in the last resort, created by those who speak as though the absence of complete certainty or the presence of any risk is in itself a sufficient condemnation.

Finally, one word about the regulator, and that in this country is the Health and Safety Commission and Executive. Whether or not a licence should be given for a nuclear power station is my business. My position, it might be thought, is a peculiar one - somewhere in between a set of political considerations about whether there should be a future for nuclear power and set of semi-scientific ones about how safe it is and whether it is safe enough.

The position may be peculiar at least, but it is and indeed has to be, tenable. My principal duty as I see it is first to ensure that I have at my disposal both the powers, and a competent technical force to ensure that nuclear power stations are properly constructed and operated to certain standards. Second, that those standards and the regulatory philosophy on which they are based, and in which I genuinely believe confidence can be placed, is available to the public and can be intelligently contested. Third, to ensure that a proper regard for the cost of safety, which can be high, is incorporated into decision making so that unreasonable demands are not enforced. And fourth, to ensure that the resources of science, number and technical experience are used to the full extent; but that they are not promoted beyond the capacity they actually have to illuminate and balance judgement.

References

Health and Safety Executive. The Tolerability of Risk from Nuclear Power Stations. London: HMSO 1988

Risk Assessment. Report of a Royal Society Study Group. London: The Royal Society, 1983

Sizewell B Public Enquiry. Report by Sir Frank Layfield. London: HMSO 1987

Health and Safety Executive:

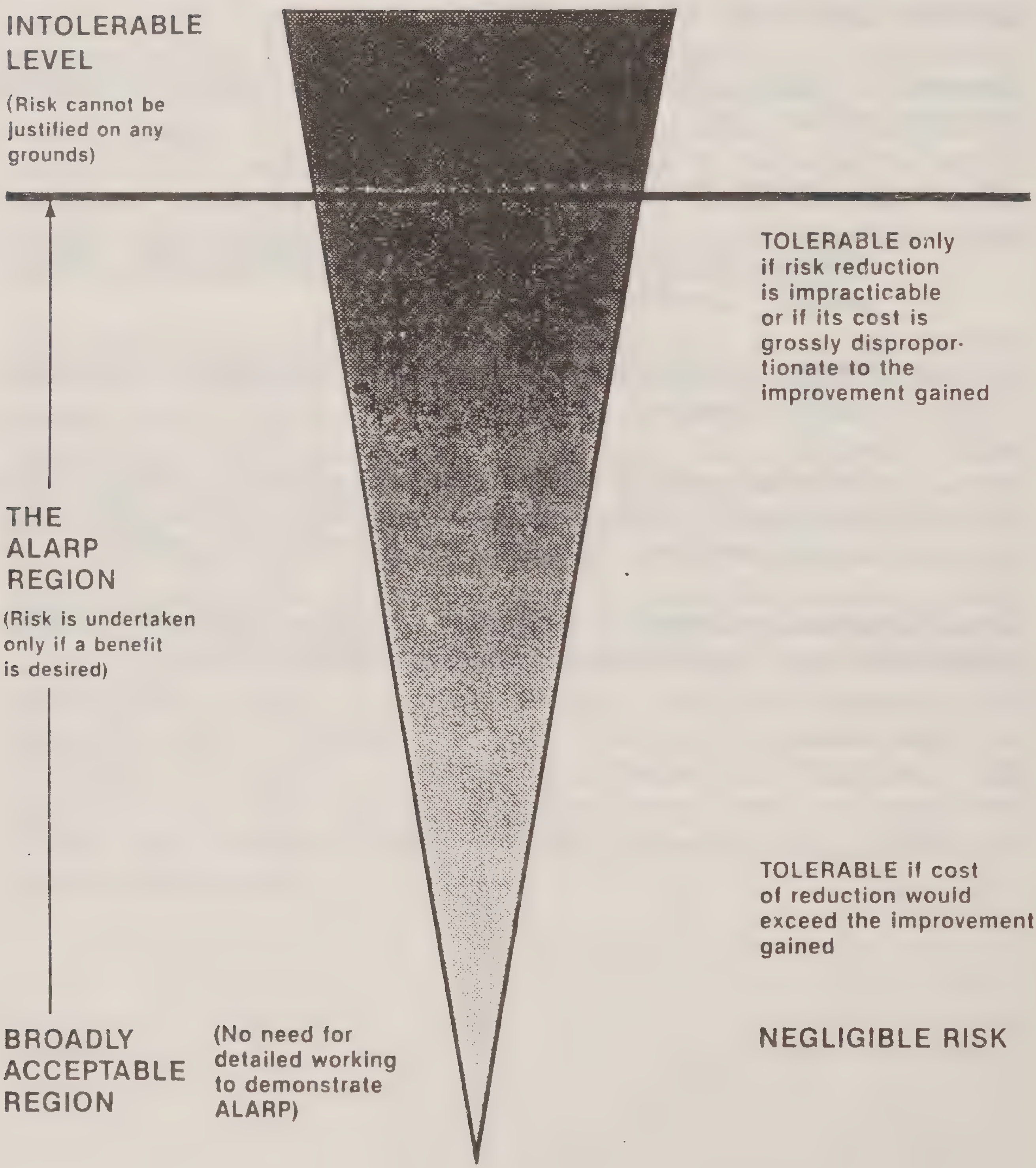
Safety Assessment of BNFL Sellafield, 1986, Vols. I and II. London: HMSO 1986.

BNFL Sellafield: Post Audit Progress, December 1987. London: HMSO 1987.

Berkeley and Bradwell Nuclear Power Stations, The findings of NII's assessment of the CEGB's long term safety review. London: HMSO 1987 and 1988.

The Flixborough Disaster: Report of the Court of Enquiry, Department of Employment. London: HMSO 1975.

LEVELS OF RISK AND ALARP



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RISK ASSESSMENT AND PUBLIC PERCEPTION

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I am often paired in this sort of session with a nuclear engineer who attempts to convince the audience using well developed technical arguments and showing you all the quantitative data on risk and so forth, and that obviously nuclear power is the way to go; and so then I have the luxury of being able to illustrate why purely technical analysis of nuclear power completely misses the mark. However, following Mr. Rimington's very thoughtful appraisal which carefully notes the limits of what quantitative analysis can do and why there is an intrinsic place for the philosopher and the moralist in these kinds of discussions, I do not have that particular kind of luxury, but I will have the opportunity instead of doing a great deal of counter punching, to perhaps do more by way of a complementary analysis to that presented by Mr. Rimington. What I will do is to take up his notation, which I completely agree with, that nuclear power is in fact a social and political phenomena as well as a risk phenomena, and I want to take his particular phrase of "the geometry of the social decision on nuclear power" which I think we all face, and to explore at some length some of the "geometry" of what that social decision on nuclear power is and why and in what ways it needs to depart from a quantitative risk assessment approach.

Let me begin by noting that, surely there are significant obstacles which are embedded in social and political concerns to the public acceptance of nuclear power. They are apparent all about us. The declining oil prices in the 1980s have certainly contributed to the difficulties with nuclear power in the sense that the benefits of this particular technology, and this is very much the case here in the UK, are certainly questionable. We have had over the past decade two major accidents with nuclear power, the first in the United States which, as people are fond of quoting in the US, probably ended up killing no-one, then Chernobyl, whose long-term implications are still to be defined. We

have also had a series of safety management problems; later on in my presentation I want to say something about why those are particularly important and are not captured in most expressions of risk, which range from the nuclear scandal in Europe recently to an event less publicised but really remarkable on a world-wide situation that occurred in Goiania, Brazil. In the States we have also had a series of revelations concerning the management, or mismanagement of nuclear weapons facilities in terms of the appropriate safety assurance of those facilities for both workers and the public. We have had, across a variety of industrial societies, uneven progress - many could be described as neglecting the nuclear waste situation; and we have that fundamental concern that lingers in the background to which Mr. Rimington referred, of that ambiguous link between nuclear power and nuclear weapons that seems to be so troubling to the public.

Significant problems are also significant opportunities; so once you look at that array of problems and say, well, yes, to a certain extent those problems have produced a hiatus in nuclear, but that's a hiatus which provides an opportunity for a variety of advanced industrial societies to re-think the assumptions that we all began the nuclear enterprise with. To a certain extent that has been forced upon you in the United Kingdom with the lengthy Sizewell proceedings which turned out not to be the normal enquiry process but became much more an enquiry on the nuclear fuel cycle as well as on a particular nuclear power plant. We have also had in the process an opportunity to begin a fundamental re-thinking process, because to a large extent, we all sort of wandered into nuclear power; it really came in many societies, out of a programme that was originally a military programme. Having some opportunity to re-think whether or not the early decisions that were made upon technology, that were made concerning that scale-up of those technologies, and the expansion to a relatively large nuclear programme in a number of countries; an opportunity to ask ourselves whether that whole process unfolded in ways that, if we went back and could re-think that process, would we in fact make the same series of decisions? And there is some important thinking which is now occurring on the nature of the technology itself, whether or not smaller nuclear power

plants are preferable to larger ones in terms of their intrinsic risk characteristics; whether or not there are intrinsically safe nuclear power plants which are preferred technology to the technologies that we are proceeding forward with. I might say, although I won't exaand upon it at this point, that I have some concerns, particularly in my own country, about how that hiatus has been used, because we have had a ten year period at least in North America, and I think it that has not been used to its maximum advantage.

Certainly, in brief, a key to success I think we would all agree, is that some basis of public acceptance is needed whatever our views of the expert comparison of risk with other kinds of technologies. The fact of the matter is, if there is not some basic change in the public assessment of nuclear power in a variety of countries, that intrinsic opportunity that nuclear power can contribute to the energy mix during this transition period between oil and renewable sources of energy, will be lost.

So I would like to turn to that now and explore it. First, I would like to note in brief some of the transient public acceptance and some of the cautions that they suggest; secondly, how do we explain this strong degree of public concern over nuclear power when many of us in the risk assessment community look at nuclear power and say, what is the problem? If you look at the risks of nuclear power in comparison with the risks of a variety of other energy sources, you wouldn't see a reason why we shouldn't go forward with nuclear power. I think many experts, even many critics, would agree upon that point. So how do we then understand that deep public concern that Mr. Rimington referred to? And finally, I will put forth what I see as a prognosis for nuclear power with the public. One of the things that has to change - one of the areas in which there has to be good performance: what are going to be the critical issues for that base of public support to exist for what some people describe as a second era of nuclear power.

Let me note briefly several characteristics of trends in public attitudes to nuclear power. Across a variety of

countries in the early history of nuclear power, from the public opinion surveys and studies of public response which were done, it was very apparent that although there was some concern about the risks of nuclear power, in fact in the early history of nuclear power the major concern came out of the scientists who were very intimately associated with the technology - they highlighted many of the value issues, which were then taken up in later periods of time by the critics. In any event, during that early period, there was very strong public support for nuclear power. In my own country the opposition really began to develop at the same time as the environmental movement in the late 1960s, and it grew during the 1970s in a way which is very interesting. It grew in a way which I think has been replicated in the experience of a number of different countries: that the issue is never the same one with nuclear power.

We started out primarily concerned in the late 1960s with the environmental effects of nuclear power - what would be the effects upon the warming of waters that were receiving the waste heat from nuclear power plant? Later that switched to the siting of nuclear power plants, specifically in relation to population densities. Then it was radioactive wastes, and yet again, nuclear proliferation, and writing in the late 1970s our group at my university thought we saw something of a Hydra quality to nuclear power, that is the Hydra monster with its variety of tentacles - cut off a particular tentacle and others grow to take its place, and those tentacles that get chopped away reappear, but the head of the monster remains immortal. Nuclear power seems to have some of that quality.

There is a basic public concern about the technology, the argument shifts from area to area, and things that you think are settled, like reactor safety for example, reappear again after the latest accident and again get onto the public agenda of concern. In Europe, it seems to me, you find a rather variable picture. In France, for example, the levels of support for nuclear power have been quite consistent although even there, particularly in the post-Chernobyl period, there have been signs of public concern and of distrust in the people managing the nuclear enterprise. In

Sweden and The Netherlands we seem to have examples of countries that are largely moving away from nuclear power. The United Kingdom, West Germany and Japan, all of which have significant nuclear programmes and are areas in which there is a major stake in nuclear power, there is a strong division in the public as to whether to move ahead with all the problems that apply to trying to manage the technology.

We learned a number of things about a very important event that occurred in the history of public concern about nuclear power - Chernobyl; opposition in the period since Chernobyl, particularly immediately following the accident increased in all the countries of Europe without exception. It increased remarkably in some countries such as Finland, Yugoslavia and Greece, where the increase in opposition was in the order of fully 30% of the population. It was more variable in France, the United Kingdom and the United States where the opposition increased by a range of about 5 - 20%.

That pattern seems to reflect several things - it is strongly correlated to the actual distribution of the dose following the accident. It is also correlated to a certain extent with how mature the nuclear debate is in many societies: the impact of the accident seemed to be greatest in countries where there was a very large segment of the population which was unsure or had not made up its mind about nuclear power. In societies where there is a very well developed debate, where the issues have been explored at length with the public having chosen sides, there was a movement of the population but also a great deal of movement back. What is interesting - at least looking at data six months later - is that although that increase in opposition to nuclear power has fallen back as it did following the Three Mile Island accident, it has not fallen back to the pre-accident levels. Whether or not roughly half of the gain in opposition that occurred following Chernobyl has remained, it will be interesting to see over time what the long-range impact of the accident has been. Certainly up until early 1988, it has had some lasting effects upon public attitudes. We also found that the media reporting was largely accurate and objective and on the whole the media seem to have performed relatively well.

Let me just conclude from this before going on, that I think 15 years of research and studies of public opposition to nuclear power have indicated a very interesting contrast between how the public and how the experts view the risks of nuclear power as a technology and as a whole. In most cases the public tend to agree with the experts about what the risks are, and, surprising to many people, if you ask the public to take 30 or 40 different technologies and to put them on a scale indicating what the relative risks of the technology to one another are, you can draw conclusions which will either make you happy if you are a doubter of the public, or that would give you confidence if you're a person that has trust in the public, because the public are actually very successful in putting them in good rank order; the public really do have a pretty good understanding of which are the risky technologies and which are those with relatively low risks. If you ask them to do the numbers, on the other hand, they are really not very good at it. They tend to overestimate the risks of technologies that have dramatic effects but small risks and they tend to underestimate some of the chronic less publicised risks such as cancer and heart disease and automobile accidents and so forth.

What is apparent I think in reviewing the response - what is in a sense remarkable about the public view of nuclear power - is that where there is a parallel between the public and the expert assessment in most cases, it is dramatically different and there is a dramatic departure in the case of nuclear power. What is going on? I think it is apparent the public does a different kind of evaluation of nuclear power than the experts. I'll come back to this, but would like to make the claim at this particular juncture that what we basically know from all these studies, is that the public assessment of technologies as a whole is broader than the approach that is taken by experts. It is not clear that risks as a concept, which is so helpful to experts in the field, is really a very useful concept to the public, or that they really tend to think in those terms. After dealing with this field for some years, I think I have become convinced that the public really do not evaluate risks per se; rather they seem to evaluate technologies, they evaluate facilities, they evaluate situations, and they evaluate management

performance but they do not evaluate that abstraction of risk. And so it is not surprising in that sense that they come to rather different kinds of opinions to those of the professional risk assessor, whose job, as it is in the Health & Safety Executive, is to try to make decisions about risk and safety.

Let me indicate some of the major reasons why I believe that the public is concerned about nuclear power, and those sort of underlying factors that will have to be taken into account if nuclear power is to go forward. The first lies in the nature of the hazard itself, and I have already alluded to that. Nuclear power has qualitative properties in its risks that, quite apart from the numbers, are things that the public are concerned about and are probably things that it is very appropriate that the public should be concerned about. We know that the public are concerned about technologies that have risks, that are potentially catastrophic. The public does not like large catastrophes. We all know and sometimes view it as irrationality, that the public does not seem to get excited about people dying one by one in certain kinds of technologies - automobile accidents are a classic case, smoking may be another - but they certainly do not like large events that produce disasters. Now you can argue for a variety of reasons that a public intolerance of disasters is actually very rational and makes a lot of sense, given the many different kinds of social impacts that disaster have. We know that the public do not like new risks, they do not like risks whose effects are particularly dreaded, such as cancer; you can therefore actually go to technical properties of risks and find that nuclear power scores actually very high on some of the qualities of technologies that people are concerned about. We've gone through the exercise at our place of trying to rank technologies. In a number of these technologies it turns out you can predict public response really quite well. One of the reasons that I cite that is that it suggests that there is a rationality that is at work in the public response but it is a different kind of rationality than looking at the numbers of fatalities as a property of the risk. The second thing is, the public is fearful of nuclear power. There are many indications that the fear is closely linked with the experience with nuclear weapons, and there's a whole history - through

literature, movies, experience with the cold war and so forth, as well as of course the original use of nuclear energy, why the public should be fearful of nuclear power; it is a big subject and I just note it here as a very fundamental property. What most needs to be said about it is that no amount of piling up documents about quantitative risk assessment is going to do anything for that fear, because the fear really operates in a different kind of pyschological basis than the rational assessment of trying to figure out what the benefits are and what the risks are.

The third issue that is very important and that I think gets far too little attention in discussions of nuclear power is perception of the benfits of nuclear power. In fact the argument that I will make is that the fundamental change-around in public opinion on nuclear power that occurred between the early 1960s and the 1980s is much less about risk than it is about benefits; there is a theoretical reason that Mr. Rimington alluded to and I suggest that if you haven't already, you look at the document on tolerability of nuclear power risks put out by the Health & Safety Executive. The theoretical reason is that there tends to be a relationship between the benefits and risks: if we see the benefits of the technology as very important, necessary to society, very strong in terms of our ability to be able to make progress and so forth, then we will tolerate high amounts of risk with the technology; that has really been the classic case of nuclear power. It has been seen as risky from the start, but it has also been seen as a very beneficial technology, and what really changed in the 1970s and early 1980s (actually, very interestingly, it occurred right after the second energy crisis of the late 1970s, when you might have thought it would have gone the other way) is that there has been a loss of the perception of benefits for this technology. People no longer see it as the beneficial technology that is too cheap to meter, that we saw in the early 1960s and even going back to the 1950s. If there is a dramatic loss in our perception of benefit, then people are going to walk away from it, they are going to say that here is a classic case where it is not worth the risk. That is the kind of phrase that people use - "It's not worth the risk". A series of interesting studies have been done in Europe and in North America which actually demonstrate that this loss of

perception of benefits did occur during that period, and so you won't be surprised as I go on, that one of the arguments that I'll make is that if this technology is going to have a second era - if it is going to go forward during the coming decade - then probably the critical area that has to change is assessment of its benefits.

The fourth issue, already alluded to, is the fact that there are major value issues involved in nuclear power and those value issues resonate in different ways in different cultural settings. I'll just note several and pass on because this too is a very big subject. Elvin Weinburg raised the very basic value issue of the impact of this technology on future generations; that is an issue which is still with us today, almost twenty years later, and the whole issue of the distribution of benefits and risks also has a series of interesting dimensions. It's the distribution of risks over generations; it's the distribution of risks between local people and regional people and distant people; between people in the Soviet Union and the rest of Europe in the Chernobyl accident; between workers and the public. There are a set of very complex processes and there are also a set of what I would describe as procedural equity problems of how decisions are made about nuclear power and the degree of candour that exists - there again the link to nuclear weapons is important.

The final issue is that of institutional trust and credibility. Nuclear power is, I think, as much a crisis or a conflict, a controversy about institutions as it is about risk. There are many different risky technologies but if you have a high degree of confidence in the institution and how that technology is deployed and how it is managed, then we seem to go forward with it even if the risks are high. And when we have a case, as we had in the United States, which I will describe now, of the Three Mile Island or the attempt to site a nuclear waste plant, which most of us do not believe involves risks that are all that powerful or impossible to deal with, then there is a crisis of institutions in many countries over nuclear power that was very apparent in the period following Chernobyl. It was apparent even in France, where some 63% of the public in a poll some months after the Chernoby accident said that they did not believe or trust the

government of France to tell the truth on nuclear power. And so this whole question of where trust has been lost in the management of nuclear power and how trust can be recovered, is a major issue. Trust will need to be recovered again if the public opinion of nuclear power is to change.

Let me sum up then what I would see as an argument for a base of public opinion: if nuclear power is to go forward, what is going to have to happen? I think the first thing that has to happen is that there has to be a demonstrated, a visible record that actually exists, of safety in performance. I think that the public is in some ways making many mistakes but they do have the ability to be able to see whether or not things seem to be going well in a technology, that there are not major events, major scandals occurring about a risk. One of the reasons why events such as the nuclear transportation issue in Europe is so troubling is that they provide an area where the public tends to make decisions differently to the technical experts - to respond to signals about technology, instead of doing calculations about benefits and risks, one of the things they see is that a certain kind of thing happens and something about what is occurring with a technology, what its risks are, and how those risks are being managed. So one of the things that is very clear is that continued risk events cannot happen in this area; this is a technology that the public is extremely concerned about and it must have, if not an event-free performance, then a clearly demonstrable record of safe performance; that is probably the most fundamental thing that has to occur. The second thing is, it seems to me, that because of the catastrophic potential of nuclear power, which is a very strong driving force in public concern, one of the things that technology can do is to develop appropriate means to limit that catastrophic potential. And so if we are able to come up with nuclear power plants that are intrinsically safer, that are basically able to divorce the technology from that catastrophic potential, that would be extremely important in shaping more favourable public response.

Third, I think that there has to be a clear separation in the military and peaceful uses of nuclear power. Nuclear power is intrinsically, as we have noted, much troubled by the

confusion between military and peaceful uses. We all know that the public tend to see these nuclear mushroom clouds around nuclear power plants, they even confuse that kind of an event with radioactive waste, all suggesting a deep concern about the possible interplay between civilian and military uses of nuclear power. Clarity needs to be introduced and a very clear distinction made in the management of the technology between those two uses; it must be clear who is going to pay for what, and what kinds of safeguards are going to be put in hand. That is an intrinsically troubling problem. We have a lot of confusion in our institutions in North America but it is not restricted to us, it's a problem that you have in part and that many other countries share. Clarity has to be introduced.

Finally, as I've already noted but I'll just add briefly, we have to rediscover the benefits of nuclear power if they exist. I think that can be done in two fundamental ways. When I was on my way here yesterday I saw " 'Nuclear Power is Greener', says Thatcher" - one of the ways that nuclear power can be seen as beneficial is to be seen as less risky than other energy technologies. If Mrs Thatcher can sustain and encourage the view that had we gone the way of France and got 60% of our electricity from nuclear power, we would not have had environmental problems - a rather exaggerated claim - and we would not have had the greenhouse effect, to the extent that the public comes to believe that other technologies such coal and so forth have greater risks than nuclear power, then that is a benefit for nuclear power. That was originally a major part of the benefit of nuclear power; but we also of course need to discover that it is less costly, that it is cost effective, and that it can help us in the transition from oil. I do however think that radioactive waste management problem is a very pervasive and troubling problem for nuclear power as a whole. In a number of countries it seems that the public has come to believe that not only has radioactive waste management not been done well, which is probably accurate in most countries, but also, which I think is not accurate, that it is an intractable problem, that radioactive waste cannot be managed. A variety of societies are essentially deferring the management of high-level nuclear waste, that is basically the approach that is being taken here in the UK;

I think that we have problems in proceeding too rapidly and introducing problems for ourselves in North America, but some significant progress on radioactive waste seems essential to the relaxation of concern about nuclear power. As long as that fundamental issue remains there will continue to be substantial concerns about nuclear power.

My final point is that fairness and equity remain the central problems throughout a whole series of decisions that are being made in this technology. I've indicated what some of those are and would like to just emphasise that they are also fundamental institutional problems in the sense that there are increasing demands being made for procedural equity as well as the substantive equity across generations, across social groups, across the public and so forth. I'd like to thank you all for inviting me from across the pond to share some of my views.

nsca

55th ANNUAL CONFERENCE
24 - 27 OCTOBER 1988
LLANDUDNO

CONFERENCE REPORT

NATIONAL SOCIETY FOR CLEAN AIR
136 North Street - Brighton BN1 1RG

CONFERENCE REPORT

Welsh welcome

Having warmly welcomed the Society - in Welsh and in English - back to Llandudno for its 55th Annual Conference, Cllr. R. Ivor Thomas, Mayor of Aberconwy, told delegates that the fight for the environment was crucial - the consequences of our actions both as individuals and collectively were becoming all too apparent; it was important to increase public awareness of pollution issues if we were to safeguard the environment for future generations.

A coordinated energy policy

"A new historic phase in the whole approach to the environment" was how Lord Ezra, keynote speaker at the conference, summed up his call for the UK to develop a coordinated energy policy; such a policy was a vital element if Britain was not to continue to be seen by its European neighbours as dragging its feet in the quest to halt destruction of the environment both at home and abroad.

It was important that such a strategy should look at future energy needs, all the various possibilities for meeting these needs - be it by nuclear or other 'benign' sources, such as windpower - and to look at their effects on the environment. A coordinated energy policy should take account, on the one hand, of minimising atmospheric pollution - both globally and nationally - and on the other, of providing the energy resources people need.

NSCA role

Lord Ezra urged the NSCA to seize the opportunity presented by the increasing recognition of the fact that the way in which we meet our energy needs needs must take full account of their environmental impact. UK energy policy - or the lack of one - was a recurrent issue throughout the conference and appropriately energy and the environment were the first topic on the first full day of the conference.

Windpower - the Energy of the future?

Clean, available and rapidly becoming economically viable, windpower could be providing 1000 MW of electricity - enough for half a million people - by 2005; this said, Dr. Philip Surman (CEGB) would save the combustion of a million tonnes of coal a year. However, he stressed that all systems of electricity generation have advantages and disadvantages, and that coal and nuclear energy are likely to remain the backbone of electricity generation.

Conservation v. generation

These two issues were complementary said Jim Skea of the University of Sussex Science Policy Research Unit; he pointed to the part that greater awareness of energy efficiency could play in energy conservation and in cutting down on air pollution; thus he questioned the CEGB'S forecasts that an additional 12 MW of generating capacity will be needed by the end of the century; he pointed out that the CEGB's present programme will bring capacity up to 64 MW as against maximum demand of 47 MW. Once again the effects of privatisation, and the "greening" of the government were seen as major factors in the effectiveness of energy conservation and generation.

Energy policy

Dr. John Chesshire also of the Univiersity of Sussex Science Policy Research Unit (SPRU) reviewed the way in which decisions on energy issues had been influenced by other major UK policy priorities and in particular the role of oil which had been seen as a "balancing fuel". Any discussion on energy policy has been linked to oil supply and pricing and not concern for the environment. He suggested that an energy policy should take into account factors such as: provision of low-cost supply; security; price stability between fuels; employment, safety and welfare; control over investment etc. And he commented on the central role that environmental considerations are likely to play in shaping future energy policy - which has not been the case so far.

In the discussion which followed, many speakers returned to the role that a coordinated energy policy could play in energy conservation. Energy efficiency should not solely be thought of as the responsibility of politicians and the energy industry; local authorities should review their policies, and architectural design has a crucial impact on energy efficiency, as does energy education.

In concluding the session on energy and the environment, Lord Nathan the Society's President supported the need for an energy policy, stressed that the enormity of the task should not be underestimated: the life of policies was often limited to the timespan between two elections - a period far too short for energy policy.

Landfill gas - an energy source

The subject of renewable energy sources was returned to later in the conference with a paper from Dr Keith Richards (Energy Technology Support Unit Harwell Laboratories) looking at the potential for landfill gas; it was he said not only rich in methane, but plentiful, relatively cheap to exploit, to a large extent benign and a "green energy'. The fact that even small landfill sites can be developed economically, and a suggestion that planning authorities should require a gas utilisation scheme for new landfill sites was warmly welcomed. Energy from this source was more likely to be used by large industrial consumers rather than domestic consumers.

Manmade mineral fibres

The fact that even energy efficiency programmes can have associated health risks was illustrated by a paper given by Professor Charles Rossiter of the London School of Hygiene and Tropical Medicine. The risks associated with asbestos which has been widely used as an insulation material are well known; concern is now beginning to focus on the line between manmade mineral fibres and lung diseases. Essentially, the links are tenuous, and may relate only to workers in the early MMMF industry when production techniques differed from modern practice. As with many investigations where epidemiological data is scattered and

confused, there is a need for further research into MMMFs, and for a precautionary approach in the meantime. As Prof. Rossiter pointed out, twenty or thirty years is too long to wait for the outcome of long term studies. In response to questions from EHOs already concerned about asbestos, Prof. Rossiter identified the use of lightweight fibres in confined spaces (loft insulation, for instance), insulation removal and very fine ceramic fibre sources as being of particular concern. Local authorities should certainly review their policies on all fibres, he said.

Noise

Neighbour and transportation noise are generating an increasing number of complaints. Dr. Les Fothergill of BRE outlined new developments in methods of insulating walls, floors and ceilings to deal with noise in buildings; Jeff Charles (Bickerdike Allen Partners) in illustrating the role that acoustic designers could play in eliminating noise, stressed the need for them to be involved at the earliest possible stage in a development; more awareness of the benefits of acoustic design in the training of architects would also be a sensible idea. Given the rather gloomy prognosis that noise from various sources (home, transport, industry and the workplace), Jeff Charles suggested that it was time to review the 1963 Wilson Report on Noise and a revised report made, At a recent meeting, NSCA's Noise Committee decided that a review should be carried out and that the Royal Commission on Environmental Pollution would be the obvious body to undertake the work.

Quieter roads

Noisy motor cycles may soon become past history if results from the static noise test developed by NSCA noise expert, David Romaine (Derby CC) and the Noise Committee continues to live up to expectations. The test which can distinguish between a 'noisy' motor cycle and one silenced to acceptable standards is to be piloted by Derbyshire Constabulary, having been given approval by the Police Legal Department and the Crown Prosecution Service.

The advantages of electric vehicles in not only reducing

noise pollution but also pollution from exhaust emissions was described in detail by Alan Aldous (Electric Vehicle Development Group). However policy and decision matters at both local and national level were being slow in realising the potential of this technology, which is being keenly developed in the USA, Japan and Germany.

Vehicle emissions

Ian Berwick (UK Petroleum Industry Association) discussed the impact of oil prices on air quality, changes in the petroleum products market between 1983-87, and how developments have affected emissions of pollutants. In 1973, he said, lead emissions were 8,400 tonnes and this figure had now fallen to 3000 tonnes;

However, he said, taking lead out of petrol had been taken primarily to pave the way for the universal application of catalytic converters, thus eliminating other vehicle emissions; and he felt that any further reduction in lead emissions would depend on making autocatalysts mandatory.

Rob Searles (Johnson Matthey, Catalytic Systems Division) agreed;

While autocatalyst technology is now well developed with 200 million being sold around the world, in the UK there has been very little take-up. There would need to be more government support if people were to be encouraged to buy 'clean cars' (a car with an autocatalyst costs roughly £250 more) in preference to other extras such as power steering, stereo etc.

In answer to a question from the floor Rob Searles assured delegates that catalytic converters should last the life of an average car (in the US they must still meet standards regulations at 50,000 miles), and also that they can be recycled, being 100 times richer in platinum metals than those dug from the ground. Cars fitted with autocatalysts can only run on unleaded petrol.

1992

The impact of the Single European Act 1986 will mean the European Commission having significant influence on inter alia environmental and pollution policy throughout member states; the concern now must be to ensure implementation in practice of the many Directives and regulations throughout Member States. Lawyer Richard Macrory (Centre for Environmental Technology, Imperial College) discussed the implications for the UK of harmonisation of standards throughout EEC Member States and the likely agenda for future EEC air pollution policies.

La Concerns

On the part of local authorities there was some concern about both the lack of any direct involvement in drafting legislation, which in the end would be their responsibility in many cases to implement; furthermore insufficient resources or manpower could make implementation as the EEC recognised it difficult to carry out,

Pollution control

Local authority representatives were also concerned about their future role in relation to HMIP. From the questions put to HMIP Director, Brian Ponsford, it was clear delegates were not convinced that the Inspectorate could be effective at present levels of staffing and resources; in particular the arrangements for inspection of Scheduled Processes came under criticism: there was also a feeling that HMIP were overly obsessed with the interests of industry at the expense of improving and enforcing pollution control measures. The long-promised revised legislation on air pollution was even more urgent.

To this latter point Brian Ponsford replied that we would "have to see", however he said that HMIP did take local authority involvement very seriously and hoped to strengthen this through recruitment, although there had been problems in recruiting an EHO to the new Local Authority Unit planned by HMIP.

Assessing risk

The UK Government's recent promotion of nuclear power generation as offering the way forward in controlling air pollution ensured a large audience for the final session of the conference: 'Civil Nuclear Power - how safe is safe enough?' John Rimington, Director of the Health and Safety Executive, explained the HSE's approach to assessing risk, with particular reference to nuclear power.

Professor Roger Kasperson of the US Hazard Assessment Group pointed to the importance of understanding and taking note of the public's perception and views of nuclear power; generally people don't like new risks, but will tolerate a risk so long as there are tangible benefits for them. For nuclear power to go forward with public confidence, he suggested the following critical factors: demonstrated record of safety performance; because the catastrophic element is a very strong force in public concern, appropriate means to limit the risk should be developed (eg safer nuclear power stations); there must be a clear separation (clarity) between military and peaceful uses; the problem of radioactive waste must be solved in such a way as to raise the level of public confidence in the ability to dispose of it safely;

From the discussion which followed it was clear that the apparent secrecy surrounding the development of nuclear power and the operation of nuclear power stations was a major factor against gaining the public's confidence in energy generation from this source; lack of knowledge and confusing information were also seen as major reasons hindering public acceptance. Perhaps, suggested one speaker, the only way to get a full debate and elucidation of all the facts and economics surrounding nuclear power would be through the development of a coordinated energy policy taking account of all sources of energy - their costs and environmental impact. The theme which had linked much of the conference.

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ANNUAL CONFERENCE
23 - 26 OCTOBER 1989
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56th CONFERENCE PROCEEDINGS

NATIONAL SOCIETY FOR CLEAN AIR
AND ENVIRONMENTAL PROTECTION

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THE GREENHOUSE EFFECT: A SCIENTIST'S PERSPECTIVE

SIR JOHN MASON, CB, DSc, FRS
PRESIDENT, NSCA

Interest in and concern with climate, climatic change, and the effect which man may have on the climate, particularly through the greenhouse effect, has reached an enormously important and crucial stage in the last year or two.

Twenty years ago nobody even discussed the climate: they were interested in weather, but were not particularly interested in the climate which was regarded as pretty well constant. However, in the last few years that picture has changed dramatically; these questions are now very high up on the political agenda of the nations of the world and in this country too. Indeed a few months ago the Prime Minister held a seminar at 10 Downing street on the greenhouse effect, attended by many of the Cabinet. So I thought that I would like to address you on the greenhouse effect because it is a very complex scientific subject as well as having great economic and political impact; there has also been much misunderstanding about it and a good deal of distortion of the scientific evidence and of the implications.

I think the public and even a good many of my scientific colleagues are really very confused about what we understand about the greenhouse effect — how good present predictions are and what we might do to improve them. What I hope to do is to separate fact from fiction and to give you an independent scientific viewpoint of what we actually know and understand about the greenhouse effect. What are the nature of the predictions we are able to make, what reliance can we place upon them and what have we to do in the future to improve our knowledge and understanding, in order to be able to give firm advice to Governments on very major policy issues? For example, major changes in energy policy will be matters of enormous economic and political significance and will affect every one of us, because at the end of the day we will all have to pay the bill.

First of all, let me remind you that, if it was not for the greenhouse effect, none of us would be here — indeed this would be a cold and lifeless planet; so let me begin by trying to explain what the greenhouse effect is.

The climate as we know it and the weather are determined by what happens in the atmosphere and the oceans; it involves what happens with the great ice masses, the sea ice, the land ice and the glaciers; to some extent and in the longer term it is also affected by the biology, by the trees and the vegetation on land; the plankton in the oceans also play a very important part, for example in controlling how much carbon dioxide we have in the atmosphere. It is an enormously complex system involving physics and chemistry and biology, extending over the whole range of sciences.

The whole climate system is driven by the heat from the sun; the amount of heat that comes in to the top of the atmosphere on average is 340 watts on every square metre. When the sunlight irradiates the top of the atmosphere and travels down through the atmosphere, some of it is reflected straight back to space by clouds. Some is absorbed in the atmosphere itself by the dust and the air and only about half actually

gets down to the earth's surface. Of that, some is reflected back to space, but most of it is absorbed by the earth and the oceans and thus warms them up. They then re-radiate some of this heat back again — not as the visible radiation which you see from the sun, but as low temperature infra-red radiation like you get from a fire, and that infra-radiation goes back into the atmosphere.

Carbon dioxide and water vapour — two of the greenhouse gases — absorb infra-red radiation emitted by the earth and send it back again to the earth and warm it up. If there were no carbon dioxide and no water vapour in the atmosphere, the average surface temperature of the earth would be -19 degrees centigrade. It is actually +15 degrees, so there is 34 degrees of warming caused simply by the greenhouse gases carbon dioxide and water vapour absorbing this infra-red radiation from the ground — that is the greenhouse effect.

The amount of heat which the carbon dioxide and water vapour radiate back to the earth's surface is 150 watts per square metre, of which about 100 watts comes from the water vapour and 50 from the carbon dioxide; another way of looking at it is that there would be 150 megawatts on every square kilometre.

If we double the amount of carbon dioxide, we should actually only increase the amount of heat from the atmosphere to the earth by 4 watts per square metre, that is by 2.5%, which is a very small change but one which may have quite large effects. To measure or even calculate these small changes of a few per cent with the required degree of accuracy is almost impossible and that is one of the problems now facing us. However, there is no question at all that the amount of carbon dioxide is increasing and most of that increase is coming from the burning of fossil fuel; the amount of carbon dioxide in the atmosphere has increased by 27% since 1860 — somewhere in the middle of the Industrial Revolution. At the moment carbon dioxide is increasing at the rate of almost exactly 0.5% per annum; at the beginning of the century the rate of increase was only 0.1% per annum, so now it is not only increasing but at an accelerating rate. The rate at which it increases in the future will be determined by several factors, with the rate at which we continue to burn fossil fuel of particular importance since about 90% of global energy supply comes from fossil fuels and wood: about 41% comes from oil, 17% from gas, 24% from coal, 14% from wood and biomass, 2% from nuclear and 2% from hydro-electricity.

Fortunately, however, not all the man-made carbon dioxide we put into the atmosphere by the burning of fossil fuel remains there, about half of it is absorbed by the oceans — by the plankton. The phyto-plankton in the oceans take up the carbon dioxide and convert it by photosynthesis into organic carbon; this is then eaten by the zoo plankton and the fish, and converted into skeletal tissue, which together with the faeces from these organisms rains out and falls to the bottom of the ocean as inorganic carbon. Vast quantities of carbon are locked up in the sediments of ocean, in the rocks and in the water itself. Thus the oceans are an important element in controlling the greenhouse effect. They also take up a good deal of the additional heat released by the greenhouse effect, which is a very important factor too.

If the amount of carbon dioxide in the atmosphere were to continue increasing at

the rate of 0.5% per annum it would reach double its pre-industrial value by about 2080 and double its present value by 2130 AD. In fact it is likely to increase above these values particularly if the world population goes on increasing. In 1958 when we began making very detailed measurements of carbon dioxide in the atmosphere, it was about 315 parts per million; it is now 350 parts per million. All the signs are that the amount of carbon dioxide in the atmosphere will certainly double between now and sometime towards the middle or end of the next century: if consumption goes on increasing at the present rate of 2% per annum and half of it still remains in the atmosphere we shall reach 600 parts per million by the year 2060, seventy years from now. Of course if we burn more fossil fuel at a higher rate we shall reach there earlier.

In the last few years we have realised that there are other greenhouse gases that man puts into the atmosphere besides carbon dioxide; these include methane, nitrous oxide and CFCs. At present they are present in minute concentrations compared with carbon dioxide — methane is about 1,750 parts per billion, and nitrous oxide about 300 parts per billion, which is a factor of 1,000 lower in concentrations than carbon dioxide. CFCs are present in only 600 parts per trillion, so there is only about one millionth as much CFC in the atmosphere as carbon dioxide. However, although they are only present in such tiny concentrations the fact is that these other gases absorb the infra-red radiation much more powerfully than carbon dioxide. One molecule of CFC for example, will absorb as much as 10,000 molecules of carbon dioxide. They are very strong absorbers of the infra-red radiation, and they are also increasing like carbon dioxide: methane is going up at 1.3% per annum, and nitrous oxide at 0.3% per annum. At the moment, carbon dioxide is responsible for about 66% of the greenhouse warming, methane about 20%, nitrous oxide about 4% and the main CFC gases about 10%. Already therefore the other trace gases are responsible for about half as much again of the heating as carbon dioxide, — carbon dioxide is responsible for two-thirds, and the others together for about one-third. If we had continued to use CFCs as we were a few years ago, the contribution of CFCs to global warming would eventually have become quite high. The impact of the Montreal Protocol which was agreed in 1987 and which aims to reduce CFCs by about 50% by the end of this century, means that they will have less effect; even so they are likely to contribute nearly 10% even at the end of the century and well into the next; if they were banned altogther by the year 2000, then their contribution to the greenhouse effect would by, say, the year 2060, be only 3%. So, while they do make a substantial contribution, they are not the major contributor, and not likely to be. However, it does seem that these trace gases are likely to contribute together about one-third of greenhouse heating, with carbon dioxide accounting for two-thirds. It is also important to remember that if you warm the atmosphere by the greenhouse gases that will mean that more water vapour will be evaporated from the surface of the oceans and the land surface. This will increase the water vapour in the atmosphere and thus magnify the overall affect, and so the water vapour will almost double the effect of the other greenhouse gases.

I mentioned earlier that carbon dioxide had increased by 27% since 1860 which on the basis of a simple calculation, should have resulted in an increase of temperature of about a quarter of a degree centigrade; I also said that there would be additional heating from the extra water vapour, and that would mean that the 27% increase in CO_2 should

on the basis of a simple calculation produce a rise in temperature of half a degree. Some scientists conclude that because the average global temperature has risen by about half a degree since 1900, the greenhouse effect is upon us, and has already started.

A glance at a temperature record from 1900 until present day shows the global average air surface temperature taken from observations all over the world, both on land and from ships. From this it could be seen that from 1900 to 1940 there was a steady increase of about 0.3° C between 1900 and 1940, and from 1940 to the very early 1970s there was a very small fall in temperature, only 0.1-0.2 of a degree; in recent years it has been increasing again and indeed the last few summers have been the warmest on record, and I suspect 1989 will also prove to have been a very warm year. This too might lead one to think that is very good evidence of greenhouse warming. However I don't believe that record shows any such thing, and I will now explain why.

Most of the warming took place between 1900 and 1940 when CO_2 was increasing very slowly, at only 0.1 per cent per annum only one-fifth of the present rate; this was followed by a cooler period from 1940 to the beginning of 1970. Although that cooling was not very much, many of you will remember that 15 years ago we were told that this was the start of an imminent ice age! The media was as full of the next ice age as it is now of the greenhouse warming; indeed the BBC mounted a two-hour programme in 1974 to convince us all that we were going to have a rapid ice age. This was all based on a little tiny drop in temperature over 25 years and the confident assumption that it would keep on plunging down into an ice age.

I believe that the temperature record of 1900 to the present day is a record of the natural fluctuations — it shows how much the yearly values vary about the average curve; there are groups of cool years and groups of warm years. Of course if the trend continues persistently, then we shall believe that the greenhouse effect has started. At the moment, however, I believe the greenhouse signal is too small for us to measure and for it to be distinguished from natural fluctuations of temperature.

But there is a more underlying reason for believing the greenhouse effect has not yet reached a detectable level. This is because, as I shall explain later, much of the heat is stored in the oceans which act just like a gigantic flywheel — they have an enormous thermal capacity enabling them to store heat and release it only very slowly; the oceans will therefore delay the greenhouse effect and indeed are delaying it, in my view by as much as 20 or 30 years. But while the oceans delay the onset of the greenhouse effect, they will also continue to release heat and prolong the greenhouse warming long after we have reduced the emissions of carbon dioxide along with the other greenhouse gases.

Why are we so concerned about the greenhouse effect when we cannot see it, cannot detect it, and nobody actually feels any effect of it? At the World Climate Conference in 1979 all these problems were discussed. We identified that the single biggest potential man-made threat to the future climate of the world was increasing carbon dioxide enhancing the greenhouse effect. It has taken ten years for governments to get that message. That prediction was made entirely on the basis of using mathematical models of the climate; the very first simple calculations were made in about 1974 but more

sophisticated models have been used since then. There are four major modelling groups in the World who can do this work, three in the United States and the UK Meteorological Office who alone have the scientific knowledge and computing power required to make this kind of prediction. We are still though, entirely dependent upon model predictions. If we are going to have to wait 10, or 20 or 30 years for the greenhouse effect to appear so that we can actually measure and detect it and be sure that it is there above the natural variability, this puts us in a difficult position. In order to give advice to governments over the next two or three decades we have to rely almost entirely on the predictions of models. At the moment the difference between the predictions of the different models are too large for us to be able to give confident advice to Government as to what is going to happen in the future.

The actual model predictions for the average surface temperature of earth due to doubling the carbon dioxide vary between 1.5 degrees to 5 degrees at the moment, and that's too big a divergence. The economic and social effects of a 5 degree warming, bearing in mind that it will be twice if not three times greater in the Polar regions would be much greater than a 1 degree change. We have to narrow that range of uncertainty in order to guide very important policy decisions.

Let me now describe very briefly the principles involved in the building of climate models and how they operate. We can describe what happens in the atmosphere and to some extent in the oceans, in terms of a set of mathematical equations which are really the laws of physics, Newton's laws of motion, equations of thermo-dynamics, the equation of radiative transfer, equations to describe how clouds and rain are formed, the evaporation of water from the surface of the earth, and hydrological cycle; all these are written down and described in terms of mathematical equations; we start with the observed status of the atmosphere at some particular incidence of time and then we solve these mathematical equations to calculate what is going to happen in the future.

The model at the Met. Office divides the atmosphere into thirteen different levels between the ground and 100,000 ft, with 30,000 points at each level — a third of a million points in all — and at these points, every twenty minutes, it calculates the following: the East-West and North-South components of the wind; the vertical component of the wind; the surface pressure; the surface temperature; the humidity of the air; how much rain or snow; the land surface temperature; the amount of moisture in the soil; the depth of the snow; the extent of the sea ice; the depth of the sea ice; the ice surface temperature; and the sea surface temperature.

To calculate all these variables, at 20 minute intervals, for just one day, involves a million, million numerical calculations on the computer. To simulate the changes for one whole year takes about ten hours on the fastest computer now available; however we need to have an even more detailed model of the atmosphere than this, and even more important, we have to have a model of the oceans linked to the atmospheric model and interacting with it in a very intimate way. At the moment we only look at the first 100 metres of the ocean but we don't actually calculate what happens in the deep oceans.

Predictions from a recent Met. Office model, presented as a series of maps, show what may happen to the world's climate if the carbon dioxide content of the atmosphere eventually reaches double its present value. In this case, the mean annual air tempera-

ture near the ground, averaged over the whole globe, is predicted to rise by 5.2 deg C. However, the warming is not uniform but varies considerably with latitude being about 4 deg C in the equatorial regions, about 5 or 6 deg C in middle latitudes, and as much as 12 deg C in polar regions in the local winter, but much less (2 or 3 deg C) in the polar summer. The temperature rise increases with increasing height in the lower atmosphere but actually falls in the lower stratosphere, which is cooled by the increased carbon dioxide. (This, incidentally, will slow down the destruction of ozone in the stratosphere — a modest bonus!) The maps also show some variations of greenhouse warming with longitude, with a tendency for greater warming over the continents than over the oceans.

The predicted changes in precipitation (rain and snow) show ever greater variations. On average, the global precipitation increases by 15%, but the increases occur mainly in high latitudes and along the tracks of the depressions in middle latitudes, while there is a reduction in rainfall in the sub-tropics in December, January and February. Earlier melting of the snow cover and exposure of the soil to higher temperatures, leads to a reduction in soil moisture in middle latitudes in summer. One concludes from these results that predictions of overall global changes are of very limited value because there are likely to be large regional and seasonal variations that are of much greater significance in respect of their impact on agriculture, forestry, water supplies and so on. A substantial reduction in rainfall or soil moisture would have a much more serious overall effect on the breadbaskets of the world than a similar percentage change in tundra or desert regions. We therefore have to improve the models' predictions to achieve greater consensus between the models, before we can be confident about estimating their impact on various sectors of the economy in different parts of the world.

The models are also very sensitive as to how one represents and treats some of the complicated physical processes, especially the formation of clouds. The Met. Office model is the only model which actually predicts the cloud; most other models predict the rainfall but assume that all the moisture falls out and does not leave any cloud behind, but then look at the satellite pictures which observe the cloud every day and put in the amount of cloud as observed from the satellite into the model.

The Met. Office model now incorporates a system for actually calculating the cloud — its area, its level, whether it consists of water drops or ice crystals. This is very important because the constitution of the cloud and its height determines how much of the radiation either coming from the sun or coming from the ground is absorbed, radiated or reflected by the clouds. The clouds therefore play an enormously important role in controlling the heat exchange between the atmosphere and the surface of the earth. As a result of actually putting in this highly sophisticated, but by no means perfect treatment of the cloud, the Met. Office have reduced their prediction from 5.2 degrees average warming due to the doubling of carbon dioxide to only 1.9 degrees, which is really a tremendous change. This shows just how sensitive the model predictions are, and it looks as though we have a very difficult time ahead of us in improving these models. The hope must be that the four big modelling centres — and maybe there will be one or two others in time — will go on improving the models, improving the physics in the models, and increasing the detail. Above all, we shall need much better observations,

because we hardly have adequate observations from the atmosphere, and very few from its oceans.

There are large areas of the World, in Africa and some other developing Countries, especially the oceans, where weather observations are worse now than they were twenty years ago. So far as the oceans are concerned, we have very few observations at all, because satellites cannot penetrate beyond the surface of the oceans. They can only see what happens at the surface, which is nevertheless extremely valuable. We can use satellites to measure variations in the height of the oceans surface with an accuracy of only a few centimetres; from this we can calculate the winds, the waves, the stress which the winds exert on the oceans, and the ocean currents near the surface; and we can measure the actual surface temperature of the ocean quite accurately.

Part of the World Climate Research Programme involves a big experiment called *The World Ocean Circulation Experiment*; this will start in 1990 and continue for at least five years. We hope to collect data from ships, submarines, and satellites etc around the world over the next five years at least, which will give us a detailed observational programme of what is happening in the oceans, both at the surface and at depth. We can then include the observations in the ocean models which the Met. Office and others are now building to link to the atmospheric models. I am quite certain in my own mind that while we understand the basis of climate, we shall not be able to predict accurately what is going to happen in the future, or what the effect of man's influence on the climate will be until we are able to model the atmosphere, oceans and the ice masses as one integrated and interactive system. We need the observations to put into the models, to test them, and also to actually measure and monitor what is happening, so that when the greenhouse warming become detectable, we shall be able to measure it and see how it progresses during coming decades. It is vital that extra resources are found for the modelling and for the observations, in the hope that as the different models improve, the answers will get closer and instead of having a divergence of 1.5 degrees to 5 degrees, all the models say it's between 2 and 3 degrees or whatever the answer may be. If they all reach similar results we shall then have much more confidence in the predictions to guide Governments in making their policy decisions — but that is going to take another ten or twenty years.

So what can we do in the meantime? Take the sea level; we read that in fifty or seventy years time, maybe much of the Antarctic may melt and the sea level will rise by up to 15 ft; this is most unlikely — it is very hard to melt ice in the Antarctic because the temperatures are so low, and even if they were raised a bit by the greenhouse effect, you can't melt much of the Antarctic ice although it is easier to melt ice in the Arctic in the Summer.

The best current estimates are that since about 1860, the sea level has risen 12 cm, of which about 7 cm is due to the melting of glaciers and the small ice caps, whilst the Greenland ice sheet has contributed about 3 cm. In Antarctica, because of increased snow fall, they believe ice mass has increased leading to a fall in the sea level by 3 cm, so the Antarctic and Greenland roughly cancel each other out; 5 cm rise in sea level comes from the fact the water has got a bit warmer and has expanded. Assuming the temperature due to the greenhouse warming will have increased by 2 degrees by the year 2050,

the best estimate is that the melting glaciers will contribute to about 13 cm, the Greenland ice sheet about 5, Antarctica about -5, (these two roughly cancel each other out), the expansion due to the water about 17, so altogether the rise of sea level if the air temperature rises by 2 degrees by 2050, will be about 33 cm, which is substantial, but is a lot different from 5 metres!

If we extrapolate to the year 2100, when the temperature rise due to carbon dioxide is, say, 4 degress, then the increase in the rise in sea level will be about 66 cm. Those calculations however contain so much uncertainty and so much error, that the errors involved in the calculations are almost as big as the predicted values themselves. So the potential rise in sea level is something to worry about, but it is not as catastrophic as some of its more alarmist statements would have us believe.

But in the meantime there are things we can do. We currently spend £100 million a year in the UK on coastal defences and it would be perfectly possible to design a system of coastal defence, which one would implement on an incremental basis in the decades ahead, and in phase to match the perceived threat as the model predictions improve; you don't have to build against 33 cm or a sea-level rise of 66 cm all at once. You would build your sea defences progressively and either speed them up or slow them down in the future, depending on the model calculations and the actual measurements. In agriculture, there is potential for plant breeding and genetic engineering; one should spread the risk in agriculture, have much more mixed farming, produce new species of plants and crops, of which some would be more drought resistant, and some more frost resistant; others would be bred to use less water, or make greater use of the increased carbon dioxide and so on. There are a whole range of defensive strategies, adaptive strategies we should be developing in order to adapt our farming and forestry, and energy policy, and coastal defences for implementation if and when required .

Fortunately we do have some time — we are talking about fifty years or more hence; it is not a lot of time, so we can't be complacent about it, but there are a lot of things we could do to prepare for these changes in climate, and to be ready to minimise their effect, as they begin to appear.

So at the moment we have to use the model calculations to guide us as to what the possibilities are in the future. My belief is that we shall be able to improve those predictions over the next ten or twenty years, to a stage that we shall have much more confidence in them. Even in these crude model calculations, we can see that the temperatures and rainfall changes are not going to be the same everywhere — they will vary greatly in space and in time; there are going to be strong regional and local variations, that will be difficult to predict.

But it seems to me that we have a very exciting and challenging task ahead to study and predict changes in the world climate and their impact, bearing in mind all the time we are looking for really quite small changes. It is one of the most exciting problems in the whole of science — and something in which, I am proud to say, the UK is in many respects a world leader.

This address has been transcribed and edited from a tape recording.

CFCs - RECOVERY, RECYCLING AND SUBSTITUTION

By

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I believe the Society has chosen to begin the Conference on an optimistic note, although you may well inquire what is there to be optimistic about with CFCs. I would submit two things: first they are being phased out, and secondly they probably represent the only aspect of the man-made contribution to the global warming problem, that thus far we have already solved. I am not suggesting complacency, in fact if I were to adopt what appears to be the currently fashionable technique of moving you to action by terrifying you, CFCs would obviously be the demon in our midst. However, what I would like to do is to take you briefly through the scientific background to the CFC ozone problem to indicate some of the regulatory things that are going on, particularly at the International level, and then to talk briefly about the response, which we as industry, and the other sectors of society can make to this particular problem.

So what was the problem with CFCs bearing in mind that when they were invented in the late 1920s they were the "Green" solution of the day - they were the environmentalists dream, they were non-toxic, non-flammable, non-corrosive, utterly stable, and replaced chemicals which were none of those things. So what went wrong?

The atmosphere above our earth is divided into layers, and the ozone layer is at the bottom end of the stratosphere. To put some perspective on this, roughly the level that Concorde flies at, while the rest of the aeroplanes are down in the troposphere; and while 30 million tons of ozone were destroyed yesterday, 30 million tons of ozone were also created yesterday. There is a natural cycle between oxygen and ozone, and what the CFCs are doing, is not destroying an irredeemable bank of ozone that is there once and for all time, but disturbing a natural balance; they do that because they contain chlorine in a form that can be released in the ozone layer, and by a form of catalysis the chlorine from the CFCs can destroy a disproportionate amount of ozone.

However, the story as with all scientific stories is not simple, and predictions from the scientific community have varied over the years. Each year from 1975 to 1985 scientific predictions of the future depletions of the ozone layer have varied; from a peak in the late 1970s at about the time when the United States banned the aerosol, there has been a considerable reduction in the amount of ozone depletion predicted, reaching perhaps a minimum in the early

1980s. Only in the mid-80s did the predictions start creeping up and new scientific evidence gave us much greater cause for concern than before. That new evidence took two forms. Firstly, the now famous, or should I say notorious Antarctic "hole", which is a phenomenon resulting from the meteorological conditions at the South Pole; essentially the Antarctica land mass is surrounded by water and during the Antarctic night, the air over the Antarctic forms a stagnant and very cold pool trapped by the vortex of winds circulating in the Southern hemisphere.

Because of the extremely low temperatures a different kind of chemistry, a surface chemistry, can take place in that region and it was that unsuspected surface chemistry that led to the implication of the CFCs in a much more dramatic depletion of ozone albeit a temporary one, and albeit geographically limited, every Spring time.

The second major piece of scientific evidence that gave us cause for concern emerged some 18 months ago. This was the executive summary of the report of the Ozone Trends Panel, a body of international scientists who using some very sophisticated statistical analysis, looked to see whether there had been any measurable ozone depletion over the generality of the earth's surface. Models at that stage had predicted that we would not yet be able to measure any ozone depletion. The models had not predicted the small but statistically significant levels of ozone depletion reported by the panel, and that again gave us some cause for concern. However, there is still some good news. The main reason why there has been concern about potential future ozone depletion, has been the hypothetical connection between ozone decrease and increase in ultra-violet radiation at the earth's surface, and the potentially damaging effects of that increase in ultra-violet radiation.

There now seems not very much residual doubt that CFCs and certain other man-made chemicals can perturb the ozone layer. At the other end of the scale, there is little doubt that a major increase in hard UV radiation at the earth's surface would have deleterious effects on human health, and possibly the environment.

The missing link appears to be in the middle, there is as yet no clear cut evidence that ultra-violet radiation is increasing at the earth's surface despite the fact that we do now have evidence, that ozone in the stratosphere is decreasing. All things being equal, certainly an ozone decrease should produce an ultra-violet increase, but as so often in life, other things are not equal, and it appears that our modelling has been too simple - we have ignored some of the feedbacks. For instance, as with the greenhouse effect, the role of cloud cover is one of the factors we are still struggling to put into the models.

We in ICI, along with some of the other companies started environmental studies on CFCs in 1972 - two years before

Rowland and Molina proposed their hypothesis that CFCs could affect the earth's ozone layer. The reason we started work in 1972, was because we had by then recognised that the atmospheric lifetime of these compounds was very long, and we felt it our social duty to try and find out what happens to the CFCs when the general public have finished using them, because most of their uses do involve emission into the atmosphere. The Rowland and Molina hypothesis followed in 1974, and a series of events with which most of you are familiar transpired during the 1970s, until in the mid 1980s, and with new scientific evidence, international concern quickly developed. This led first to the Vienna Convention, and then later to the Montreal Protocol of September 1987.

The Protocol tries to encourage worldwide compliance by a variety of trade sanctions and also makes special provision for the developing countries, recognising their particular needs, for the social goods which CFCs in the past have provided. The Montreal Protocol contains its own provisions for revision and with just the hindsight of two years we can see the wisdom of that, inasmuch as the more recent scientific developments have clearly indicated that the Montreal Protocol in its present form is no longer an adequate response to the environmental problem. Once again, I believe that most governments, most industry and most environmental groups are at one, in recognising that our goal must be the complete phaseout of the CFCs.

Using the revision mechanisms built into the Montreal Protocol this process has already started. In The Hague, in Autumn 1988, the United Nations Environment Programme established a number of working groups to provide the factual basis for a revision, looking at the new scientific evidence, the potential effects of increased UV radiation, the economic effects of regulation, and looking at the technological options for substitution.

The first meeting of the parties in Helsinki in Spring 1989 emphatically recognised the need for revision; we continued in Nairobi at the end of August with the first round of negotiations at the United Nations level. This resulted in a wide acceptance of the scientific basis for the revision, and the emergence of specific proposals. The options should be finalised in November in Geneva, culminating in the London meeting of June 1990, hosted by the UK Government, at which the Protocol parties will review and create an amended Protocol which is expected to be far more stringent than the original.

An environmental goal now widely accepted is the achievement of a level of two parts per billion of chlorine in the atmosphere - the level immediately preceding the Antarctic hole, at which time, there was little or no evidence for any significant atmospheric disturbance. Even with the most stringent option - that is total and absolute elimination of CFCs - it will take us until the middle of next century to

achieve that goal. That is the bad news; the good news is that because of the long time constants involved we do have a number of options within that, some of which would be highly disruptive to society, and some of which would carry smaller economic penalties and, while accepting that an economic penalty is worth paying for an environmental benefit, I submit there is little value in an economic penalty **without** significant environmental benefit.

It is worth noting that the result of getting only 80% international compliance, with a revised protocol, results in a levelling out of chlorine at three parts per billion, thus highlighting the absolute need of getting nearly 100% international compliance. To do that, we must clearly not set the initial hurdles so high that other countries refuse to join us in this environmental struggle. The UNEP meeting in Nairobi proposed schedules for CFCs which involve something like a 50% cutback by 1995 (three years earlier than envisaged in the original Protocol), 85% cutback by 1998 (whereas the original protocol had 50% in 1998) and 95% plus by the year 2000. There is still some debate about the last 5% and whether you allow a few final years for those very difficult to solve uses for CFCs.
Halons, the fire fighting analogues of CFCs, in the Protocol are merely frozen at 1986 levels; the new proposals are suggesting a 50% cutback by the mid 90s, and an ultimate phaseout by the turn of the century. Carbon tetrachloride is not used in the Western World to any great extent in dispersive uses, but its potential for depleting ozone is even greater than that of the CFCs and clearly so far as dispersive uses are concerned these should also be phased out. Methyl chloroform is an industrial solvent with a small ozone depletion potential but a high tonnage, and multiplying these two factors together has made it a candidate for attention, although the particular future of that compound is not yet satisfactorily resolved. HCFCs and the alternative fluorocarbons were widely regarded as being for the present part of the solution, and there was clear consensus on this in Nairobi. Too much negativism about them will merely mean that industry does not invest in them - neither we as producers nor our customers as potential users - and that will make the task of eliminating CFCs infinitely more difficult.

Admittedly some of the substitutes are not perfect, but the international community is now anxious not to make perfection the enemy of the good. So long as we accept that there is a need always to **strive** for perfection and that **eventually** we may wish also to dispense with these compounds, to dispense with them in the next few decades would be a folly of the highest order - it would be merely a short term political expediency and inflict environmental problems on our children.

So how are we going to get rid of the CFCs: a very broad picture would show 30% by conservation, 30% by replacements that are nothing to do with fluorocarbons, and the remaining

30% or 40% by new fluorocarbon chemicals. Conservation is perhaps the area in which local government and the private citizen have the biggest role to play. Time will not permit me to go through the options in any detail but let me just take you through the highlights.

Control of emissions is as always a critical issue; ideally we should minimise the emission of any man-made chemical into the environment, whether it be to air or water, and that is an area in which local government, national government and industry can work well together.

Recovery and recycling of the existing CFCs is also an immediate measure that we can take to reduce our dependence upon them; we can't get rid of them overnight, because the results for society would be frankly unacceptable, both to society itself, and certainly politically. However, we can minimise the need for new production by recycling and recovering wherever possible and ultimately, where we cannot recover and recycle, by destroying in an environmentally acceptable fashion.

Many such schemes are now underway in the solvent area and we as a company and indeed other companies too, have introduced recovery services; new solvent cleaning plants equipped with facilities for distillation and re-use are now the order of the day. It must be remembered that our customers require time for adjustment - you cannot expect every metal working company in the land to go out tomorrow and buy a new cleaning machine.

Refrigerant recovery and recyling have attracted a great deal of attention. We already have recovery and recycling systems in place in this country, and increasingly overseas for commercial refrigeration. That was our first priority, because despite the high political attention that domestic refrigerators have received, they actually account for far less than 1% of the CFC burden. We are not ignoring that problem, as we recognise that the private citizen has a strong desire to participate in solving the problem; we are putting into place mechanisms to assist the private citizen largely through local authorities to dispose of the 4ozs of refrigerant in their domestic refrigerator in a responsible fashion.

We believe that local authorities do have a role to play in terms of the link between the private citizen and large companies like ourselves. We are not going to send out a fleet of lorries to every private house to remove refrigerators. I would submit that the effects of the vehicle emissions both on the troposhere and on greenhouse warming would more than counter-balance any gain from removing a very small amount of CFCs. Clearly, however, through an inverse distribution network, it should be possible to get a lot of this material back into the plant for recycling, or into destruction facilities.

Many uses of CFCs can be dealt with using existing chemicals, and wherever possible that should be done. Equally a large part of the market can be dealt with using new technologies. However, something like a third of the market - maybe as much as 40% - requires the use of new chemicals, and the only chemicals which are known to us today which present the right array of properties and environment friendliness are variants on the fluorocarbon theme. Some of these alternatives have no ozone depletion potential, others admittedly do have a small ozone depletion potential, but they are the best that we have got at this time, and probably the best we are going to have for some decades. Chemicals cannot be invented overnight. To help the atmosphere to recover there is a small environmental price to be paid, and I think mature judgement would lead us to believe that if that is the best you can do today, let's do that now and in the future strive to do even better.

The chlorofluorocarbons are also going to make a significant contribution to greenhouse warming for some years to come, simply based on those already in the atmosphere, because their atmospheric lifetime is so long. Up to the year 2030 they will still be representing 10% - 15% of the problem, even though we will have phased them out in the year 2000. Once again it should be borne in mind that no gas is totally without some greenhouse warming potential, certainly no gas with carbon-fluorine bonds in it, given its infra-red spectrum. However, if their atmospheric lifetime is short, then their contribution will be very small, and reversibility will be available to us.

Finally, we are of course as an industry working very hard on alternative fluorocarbons, but now is not the time for me to detail all of their chemistry and applications. I would just like to end by indicating two areas of co-operative international endeavour in which industry is involved. We are very conscious of the responsibility we bear, to ensure that the new fluorocarbons are not a leap from the frying pan into the fire.

First we are - whether you choose to believe it or not - ethical individuals and ethical individuals in composite, tend to make ethical companies. If you don't want to believe that, then let me ask you to believe that if we are investing, as we are, hundreds of millions, indeed billions of dollars in new plants and new production facilities for new chemicals, this would be very foolish unless we were extremely certain that it was not a wasted investment, and that the chemicals to be produced would be acceptable to society for decades to come. After all we want to recover our investment.

So we have mounted two major initiatives, funded totally by industry. The first, AFEAS, the Alternative Fluorocarbon Environmental Acceptability Study, has completed its first phase with a meeting in Boulder, Colorado in May 1989. We set out by employing one hundred of the world's best

scientists in the relevant fields of endeavour to review what was already known about the environmental behaviour of the chemicals we are proposing, and as far as possible to extrapolate and predict what they would do in the environment. The results of that conference received sufficient consensus that they have now been adopted by the United Nations, as part of the science review under the revision of the Montreal Protocol. Some environmental issues were firmly laid to rest; for example, we feel absolutely certain that these compounds will contribute nothing to acid rain, and nothing to tropospheric ozone or urban smog, and we are confident that the initial breakdown products are innocuous. There are still some unanswered questions. I am involved on behalf of ICI in setting up a continuation of this programme to study some of the issues that have not yet been satisfactorily resolved, such as the secondary and tertiary breakdown products. By and large the concentrations are so minute, that it is unlikely that they would have any significant effect; we have already reached the point in that we are confident enough to make major investments, and to ask our customers to do the same thing.

Equally, on human health, the programme for alternative fluorocarbon toxicology testing has now reached a stage where in September in Toulouse, France, we announced results of toxicology testing, and I am delighted to say that they were uniformly favourable with regard to the front running compounds. Work is continuing - these tests do take a long time - but as far as the absolute front runner is concerned 134A, which is currently the major alternative refrigerant, the outcome of the toxicology testing was excellent and it appears to have one of the cleanest bills of health of any chemical; it has already been tested more than most other industrial chemicals, but we will continue with that testing, so that we can offer, if not only for industrial use, but for consumer use and for medical use, which clearly reflects very stringent standards of assurance on toxicology.

There is one negative conclusion from all of this and that is that the environmental testing is going to be costing something on the region of US $10 million. The toxicological testing has already cost on the order of US $25 million. While as industry it is our duty to spend the money on thorough testing, in all reality it does limit the amount of new compounds we can offer; and if we are limited in what we can offer, then equally governments and society are limited in how rapidly they can get away from the old CFCS.

One of the difficulties that I often encounter is that the general public and even professionals, are often not aware of how widely CFCs are used, and how so many different aspects of our society are dependent on them. In fact if you start analysing it, CFCs now form a thread through the fabric of our society, and the task that we jointly share is to unravel that thread, without tearing the fabric. To do

that, clearly we must minimise the effect of man-made chemicals on the atmosphere. We must support not only the Montreal Protocol, but its revision and compliance internationally with it, bearing in mind the special needs of the developing countries.

The role that CFCs have played has been crucial to society: our food chain depends on it, temperature control without which much of the industry and much of the medical profession could not operate depends on it; in hot climates safety depends on it in terms of air-conditioning; electronics depends almost totally on it; as well as firefighting to a large extent.

However, to end on the note that all's well that ends well, I do believe that all elements of society have agreed on the goal, and we are slowly coming to consensus on the best way to reach it. We are all environmentalists now; green is certainly the colour of the week if not the year, and probably the decade. However, beautiful colour though it is, it would give us a very monochrome world, and we do have other considerations that we have to think about along with the natural and proper desire to protect the environment that we share.

CLIMATIC IMPLICATIONS OF REDUCING GREENHOUSE GAS EMISSIONS

By

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This paper discusses the effects of reducing greenhouse gas emissions on global warming. To set the scene, the greenhouse effect will first be reviewed. This review provides the foundation for understanding the broad effects of policies for emission reductions, as presented in the second half of the paper.

The major greenhouse gases

The major gases contributing to the greenhouse effect are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the chlorofluorocarbons (the CFCs).

Figure 1a shows the increase in atmospheric concentrations of CO_2, as measured at Mauna Loa, Hawaii from 1958 to 1984. CO_2 concentrations increased steadily over this period during which precise measurements were made. Until quite recently, there was considerable uncertainty regarding the concentrations of CO_2 for earlier periods. This uncertainty has been reduced by analyses of air bubbles contained within cores extracted from the polar ice sheets. This procedure has established the "pre-industrial" (mid-eighteenth century) CO_2 concentration within a narrow range of uncertainty (Figure 1b), with a best estimate of approximately 280ppmv (parts per million by volume), as compared to today's concentration of about 353ppmv. Thus, the CO_2 concentration has increased by about 25% since pre-industrial times. Most of the current increase in CO_2 originates from the combustion of fossil fuels; deforestation and land-use changes account for about 20% of current emissions. Anthropogenic emissions of CO_2 are currently growing at about 1.5% per year, causing a growth in atmospheric concentration of about 0.5% per year.

The present concentration of CH_4 is about 1700ppbv (parts per billion by volume), more than double the pre-industrial concentration (800ppbv). Over the last decade, the concentration increased linearly at about 17ppbv annually. The sources of increase in CH_4 concentration are uncertain; a large portion may derive from rice paddy production, the rearing of ruminants (e.g. cows), biomass burning and natural gas releases.

The concentration of N_2O has increased from about 290ppbv to

310ppbv over the last 25 years. The current growth rate is about 0.3% per year. The increasing concentration is believed to result from the use of chemical fertilisers, fossil fuel combustion and soil disturbance, but the uncertainties are large.

CFCs are very powerful and long-lived greenhouse gases. CFC-11 and CFC-12, the most important CFCs, are, molecule for molecule, many thousands of times more powerful as CO2 in their radiative effects. CFCs account for about 20% of recent changes in radiative forcing due to greenhouse gases. Recent growth rates in the atmospheric concentration of the most important CFCs have been about 5% per year. CFCs are artificial additions to the atmosphere, resulting from their manufacture for refrigerator fluids, aerosol can propellants, solvents and blowing agents for foam packaging, among may uses.

The observed global temperature

If greenhouse gas concentrations have been increasing, has the world warmed already? Figure 2 shows a recent analysis of the global temperature record from 1860 to 1988. The yearly values are global-mean temperature departures from a common reference period. There is considerable year-to-year and decade-to-decade variation in the temperature, even when averaged on the global scale. If the temporal fluctuations are smoothed out, a warming of about 0.5 degrees Centigrade is evident over the entire period. This has not been a steady increase; a warming trend is evident up to about 1940, followed by little change until the mid-1970s, when global warming resumed.

This warming does not necessarily mean that the greenhouse effect has been detected. Volcanic eruptions, variations in solar output, changes in ocean circulation and other factors influence the climate system. Until these factors have been sorted out we cannot adequately explain the observed temperature curve.

However, greenhouse gases cannot be excluded as a possible cause of the observed global warming. Climate models indicate that, due to past increases in greenhouse gas concentrations, the world should have warmed somewhat between 0.4 degrees and 1.4 degrees by now. The observed 0.5 degree Centigrade increase falls within this range.

Future global warming

Future warming depends on three major factors, namely, the future concentrations of the greenhouse gases, the sensitivity of climate and the thermal inertia of the oceans.

Figure 3 shows the range of uncertainty in future radiative forcing changes from increasing greenhouse gas concentrations. The changes in the radiative forcing from

each greenhouse gas has been calculated and combined, and then converted back to equivalent C02 concentrations. This enables their comparison in a single line. The best "guess" is that there will be an equivalent doubling of the pre-industrial C02 level around the year 2030 - a "business as usual" scenario. However, if we increase the growth rate of emissions without regard for the environmental consequences, an equivalent doubling may take place around the year 2015. On the other hand, if stringent policy measures are adopted a doubling may be delayed until about 2050.

The second major uncertainty is the sensitivity of climate to such a doubling. The estimation of the climate sensitivity involves the use of climate models, particularly general circulation models (GCMs). In C02 experiments, these models are used to simulate the world's climate with a base level of C02 (e.g.300ppmv). The models are run until the climate has settled down to a steady state - equilibrium - condition. They are then re-run to equilibrium with double the C02 concentration (600ppmv). The resultant climates are then compared. The difference between the two climates is a measure of the sensitivity of climate to a doubling of the greenhouse gas concentration. The global-mean surface air temperature is the most common parameter used to compare the two climate states - the equilibrium temperature change for a C02 doubling. The current scientific consensus is that climate sensitivity lies in the range of 1.5-4.5 degrees Centigrade for an equivalent C02 doubling.

Finally, the GCM results discussed so far represent equilibrium temperature changes and say nothing about the rate of change. Global warming would only occur with some time lag, due primarily to the thermal inertia of the oceans. The oceans have a large capacity to absorb heat, causing a delay in the actual - or "transient" - warming. The rate of oceanic heat uptake, and thus the delay, is uncertain. Most GCM results do not take this into account. Simpler transient climate response models that include oceanic heat uptake are used instead, and provide us with projections of warming into the future.

Considering the uncertainties related to the major factors discussed above, estimates of the future warming can be made. As shown in Figure 4, the most "optimistic" case (i.e. taking the lower values within the range of uncertainties) a warming of 0.5 degrees Centigrade might be expected by the year 2030. The "pessimistic" case gives 2.5 degrees by 2030. The combination of "best estimates" indicates that the world should be about 1-2 degrees warmer than it is today by the year 2030.

An average global warming of 1-2 degrees may not sound like much, but in comparison to past climatic changes it is very large. In global terms, the Little Ice Age was about 0.5-1.0 degrees Centigrade cooler than today. The world was

about 0.5-1.0 degrees Centigrade warmer than today during the Hypsithermal, about 6000-9000 years ago, when global patterns of climate and environment were quite different from today. For a world 1-2 degrees warmer, we must go back in climate history to the Eemian Interglacial, about 120,000 years ago.

Effects of gas emission reductions on global warming

Options for societal response to global warming range from passive adaptation to changing climate, to reducing greenhouse gas emissions in an effort to slow global warming. What are the climatic implications of the latter course of action?

In order to answer this question, an integrated Greenhouse Gas Policy Model, developed at the Climatic Research Unit, University of East Anglia, was used. This computer model simplifies and integrates the more complicated climate models, allowing policy questions to be asked and answered quickly. As input to the model, three different scenarios were constructed (Figure 5).

The first, "business-as-usual" scenario assumes that C02 emissions maintain a 1.5% growth rate and that the biosphere will continue to contribute 1.5 gigatonnes C02 per year, mostly through deforestation. The growth rates of CH4 and N20 are kept the same as today, but it has been assumed that the production of CFCs will conform to the Montreal Protocol. The second option (CFC phase-out) involves the phasing out of all "greenhouse CFCs" by the year 2000. The third option is the CFC phase-out plus C02 emission control. This latter option represents a moderately strong scenario in which the growth rate of fossil fuel emissions is cut in half by the year 2005 and zero growth is achieved by 2020, while deforestation is halted.

The top curve (A) of Figure 6 illustrates the best-estimate warming that would occur with the "business-as-usual" scenario. This gives a warming of 1.4 degrees Centigrade by the year 2030. The CFC phase-out (curve B) results in a warming of 1.3 degrees, while the CFC + C02-control (curve C) leads to a warming of 1.1 degrees by 2030.

These results can be interpreted in two ways. If one assumes a "go slow on policy" stance, it can be argued that, since substantial warming will occur in any event (due to the warming already "in the pipeline" as a result of past emission and the lag effect), expensive emission controls should not be imposed rashly. The benefits, in terms of climate change prevented (i.e.0.3 degrees for option 3) are small.

If one assumes an "action now on policy" stance, these results can be interpreted quite differently. Comparing curves A and C, the warming of 1.4 degrees Centigrade is delayed for about 15 years with strong policy. In effect,

we would gain 15 years in which to develop new crop varieties, change land-use patterns and reduce our vulnerability to climate change. Moreover, the rate of warming implied is much slower. For some plant and animal species, the rate of climate change will be more important than the absolute change as ecosystems attempt to adapt.

Emission reductions: now or later?

An example of the effects of delaying emission reductions is shown in Figure 7. Here, a scenario of C02 control only (following the C02 reduction assumptions in option 3, Figure 5) is used. A strategy in which reductions are started now (bottom curve) is compared to one in which implementation is delayed for 15 years (top curve). By the year 2030, the difference between the two strategies is only 0.2 degrees.

Again, the interpretations are twofold. From the "go slow on policy" stance, one could argue that a 0.2 degrees difference in warming will not make that much difference. Why not wait until we have better scientific information? From the "action now on policy" stance, one could point out that there is obviously a long lag time between strategy implementation and climate response. Thus, if we wish to slow global warming in the long term, we should get started immediately, since the climate system is going to take a long time to respond.

What should we do? Summary and conclusions

Science can provide answers to the questions "What can we do?" and "What are the climatic implications?" But the answer to the question "What should we do?" requires personal and political judgements.

As discussed above, there are both certainties and uncertainties with respect to the "greenhouse effect". It is well established that the atmospheric concentrations of greenhouse gases have increased and that they will continue to increase in the coming decades, even with stringent policy measures. It is also very likely that such increases will cause the global climate to warm. The magnitude of the warming, however, is subject to debate. Considering the full range of uncertainty, the world will be somewhere between 0.5 degrees and 2.5 degrees Centigrade, with a best-estimate of 1-2 degrees, by the year 2030.

The world is committed to a substantial portion of this future warming regardless of what we do to reduce emissions in the short term. This is due to past emissions and lags in the climate system. For this reason, the benefits of emission reduction strategies that are implemented today will be reaped largely in the more distant future (after 4-5 decades).

Thus, the answer to the question "What should we do?" depends crucially on the extent to which the future is

discounted. If the future is heavily discounted, we are led to the conclusion that the best strategy is to do nothing - accept "business as usual" - or to delay decisions until more scientific information is available. By looking forward only to the next 30-40 years, pitifully little global warming can be prevented by relatively strong emission reduction strategies.

If, on the other hand, we set our sights beyond the middle of the next century and place high value on the world for generations to come, we are forced to seriously consider measures for cutting the emissions of CO_2 and other greenhouse gases as soon as possible. Action is needed now to steer a course away from major alterations in the global climate. The longer we wait, the larger the warming.

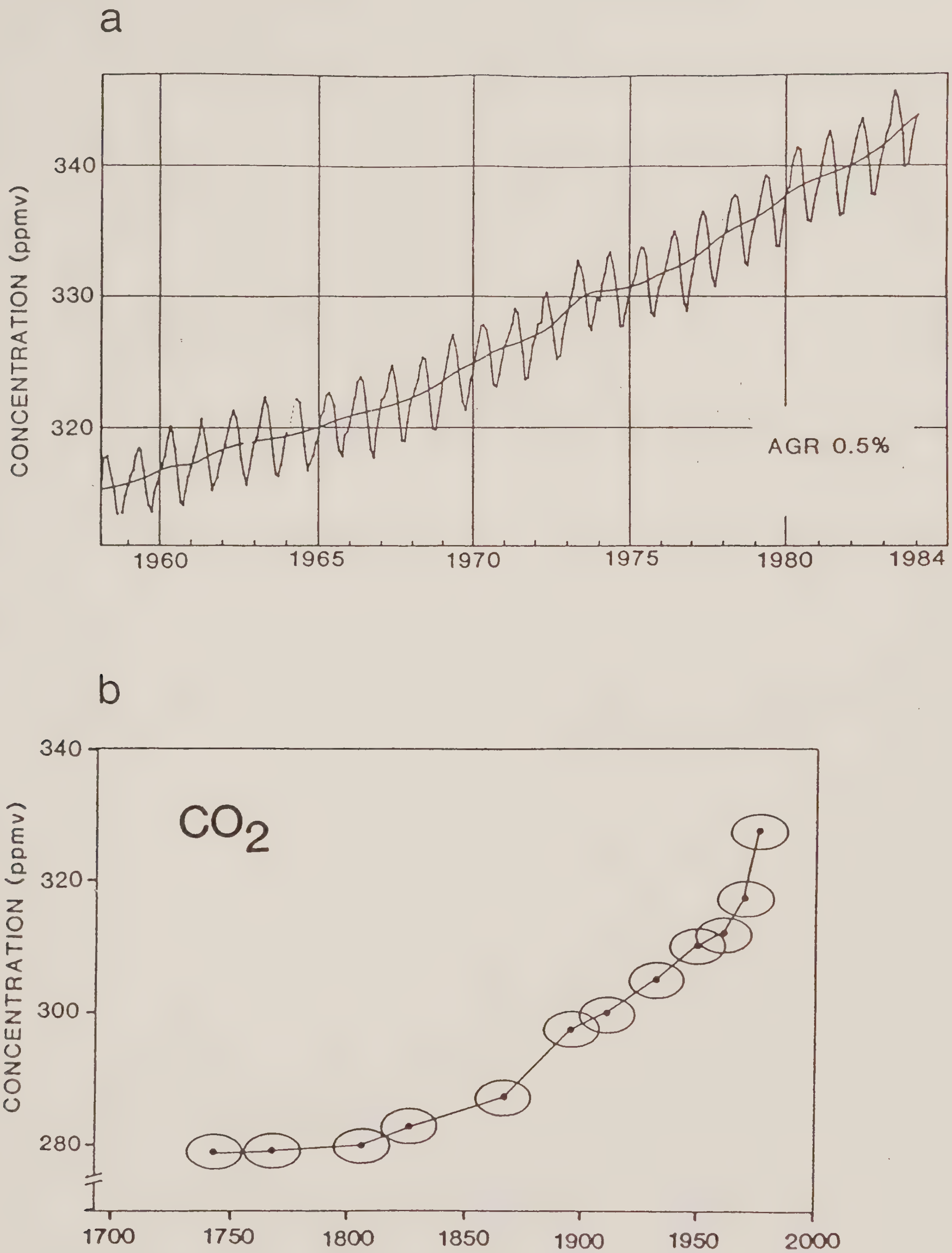

Figure 1: Increasing atmospheric concentrations of carbon dioxide, (a) from 1958 to 1984 as measured at Mauna Loa Observatory, Hawaii, and (b) as derived from ice core analyses (Neftel et al. 1985). Source: Bolin et al 1986.

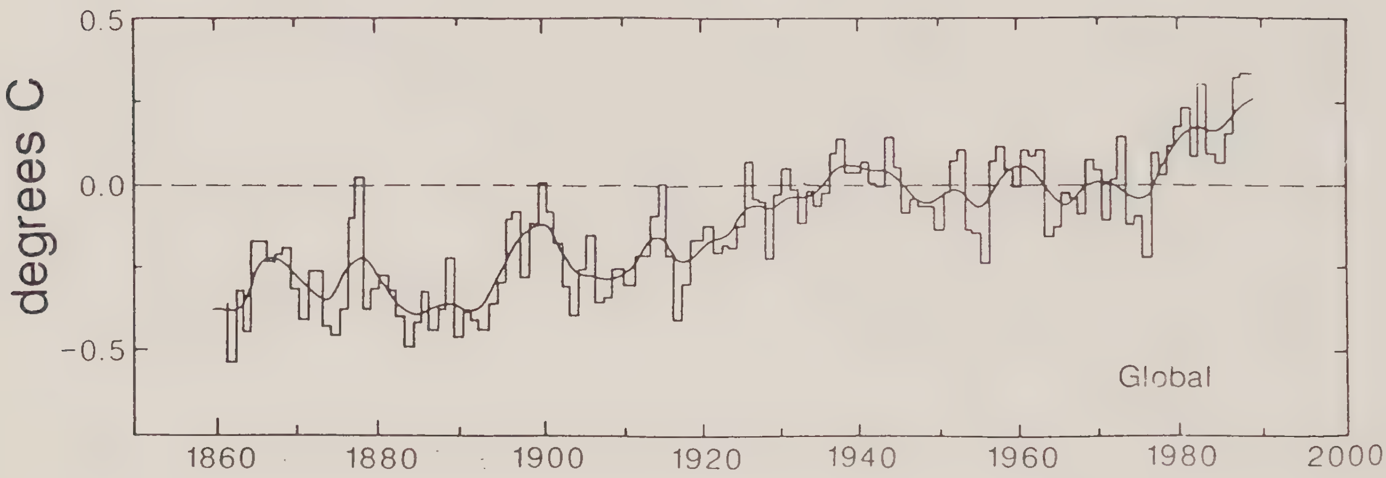

Figure 2: Global-mean temperature anomalies, 1860-1988. Source: updated from Jones et al 1988.

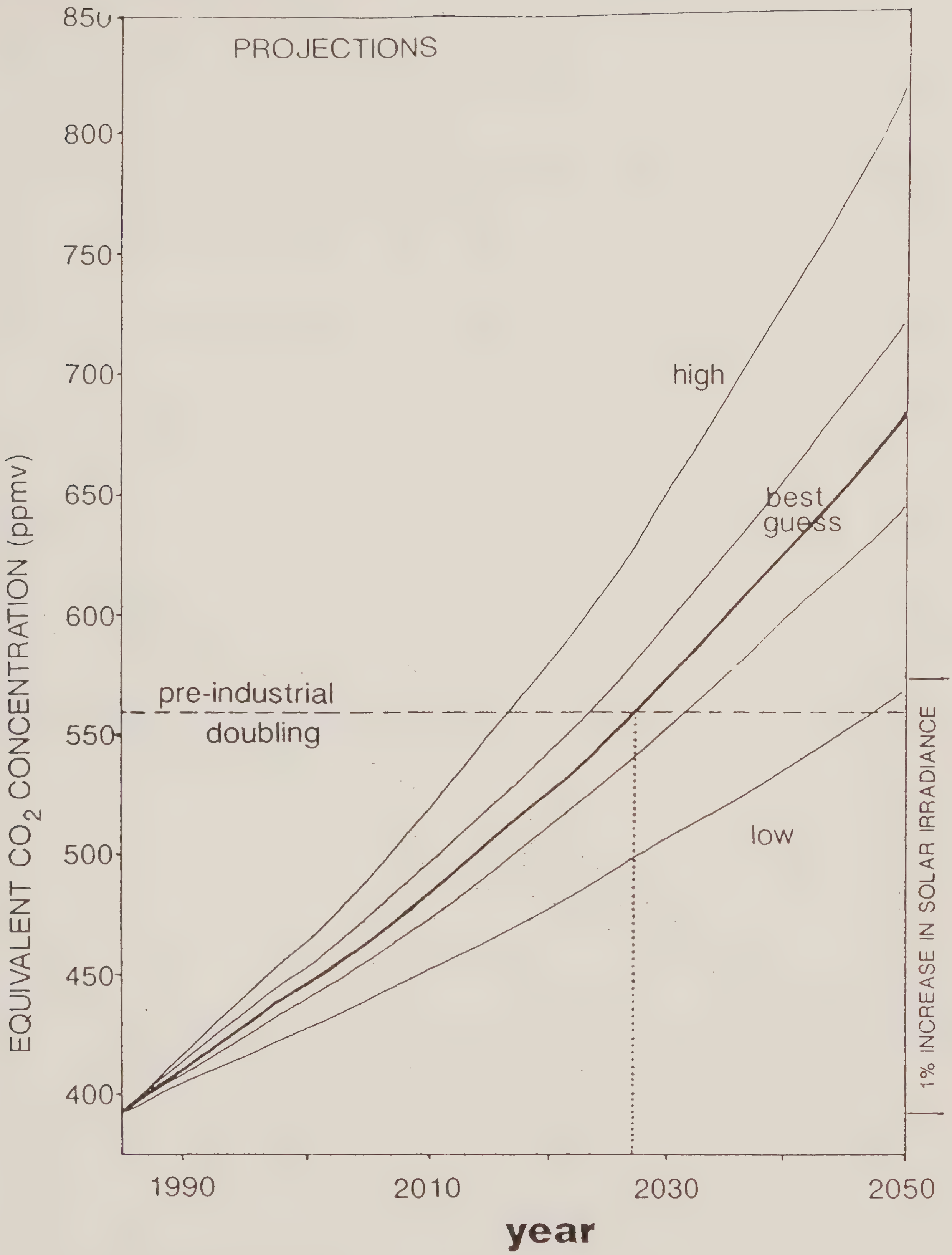

Figure 3: Projections of changes in radiative forcing due to increasing greenhouse gas concentrations, 1990-2050 (expressed in equivalent CO_2 concentration and relative to pre-industrial CO_2 concentration).

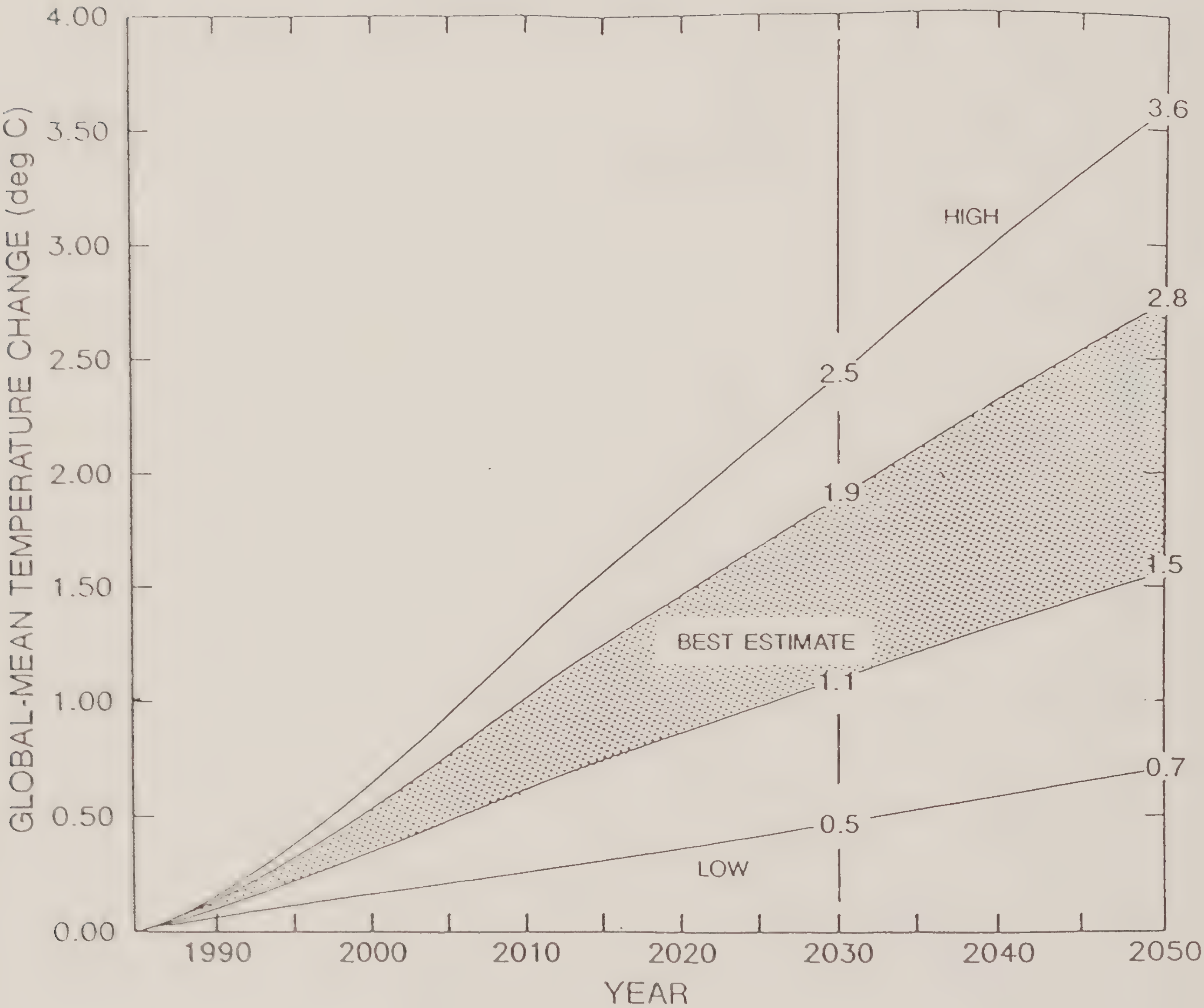

Figure 4: Global-mean temperature change, 1985-2050. Source: Wigley, 1989.

GREENHOUSE GAS SCENARIOS 1990-2050

(1) BUSINESS AS USUAL

CO_2: FF emissions - 1.5% growth
net biosphere - 1.5 GtC/yr

CH_4: 17ppbv/yr

N_2O: 0.35% conc. growth

CFCs: Montreal Protocol applies

(2) CFC PHASE-OUT

CFCs: zero production by 2000

CO_2, CH_4, N_2O: same as (1)

(3) CFC + CO_2 CONTROL

CO_2: FF emissions - 0.75% growth by 2005
zero growth by 2020

net biosphere - zero by 2005

CH_4, N_2O: slight reduction in conc. growth

CFCs: same as (2)

Figure 5: Three greenhouse gas forcing scenarios and their assumptions.

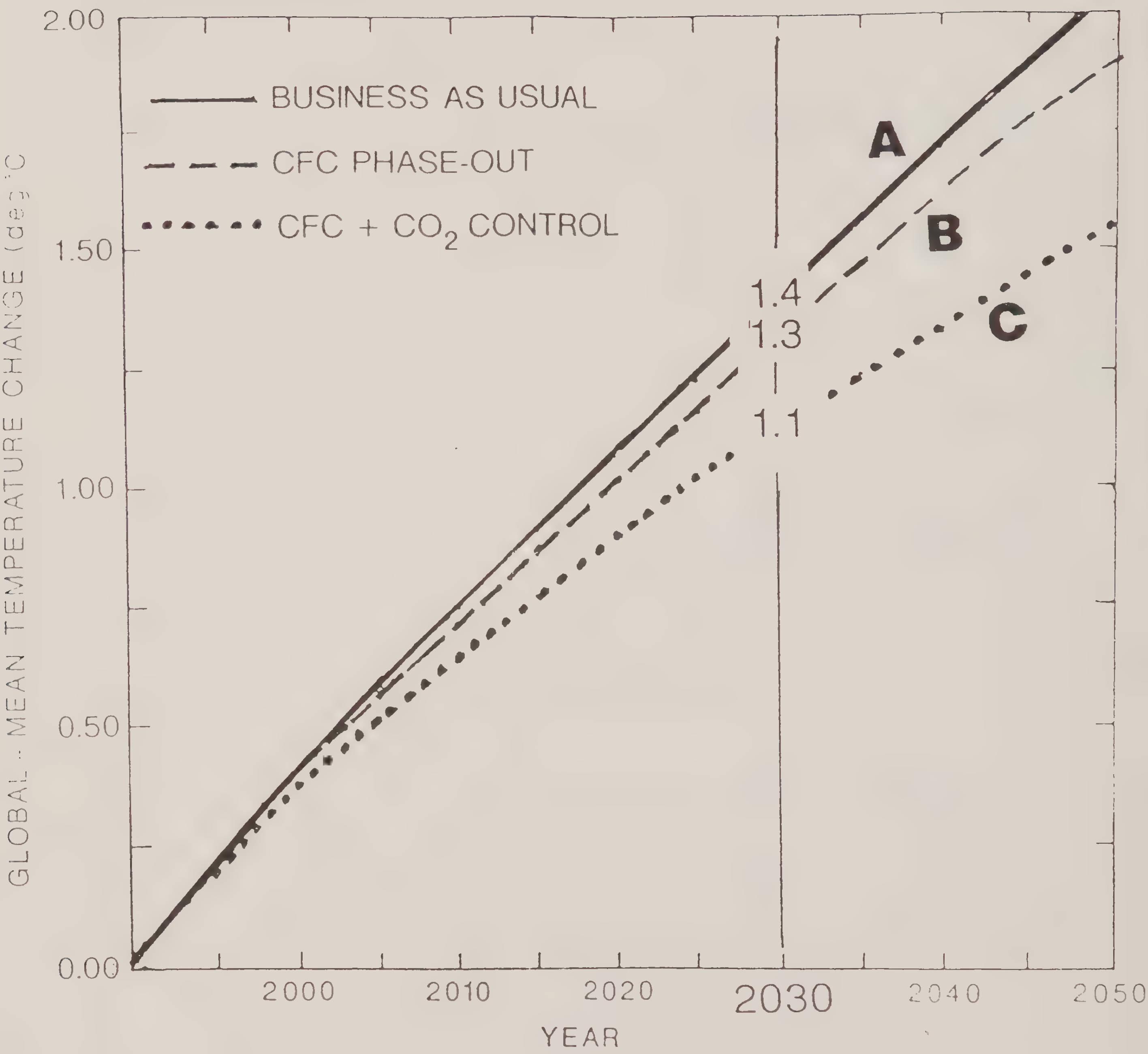

Figure 6: Global warming projections for each of the three scenarios noted in Figure 5.

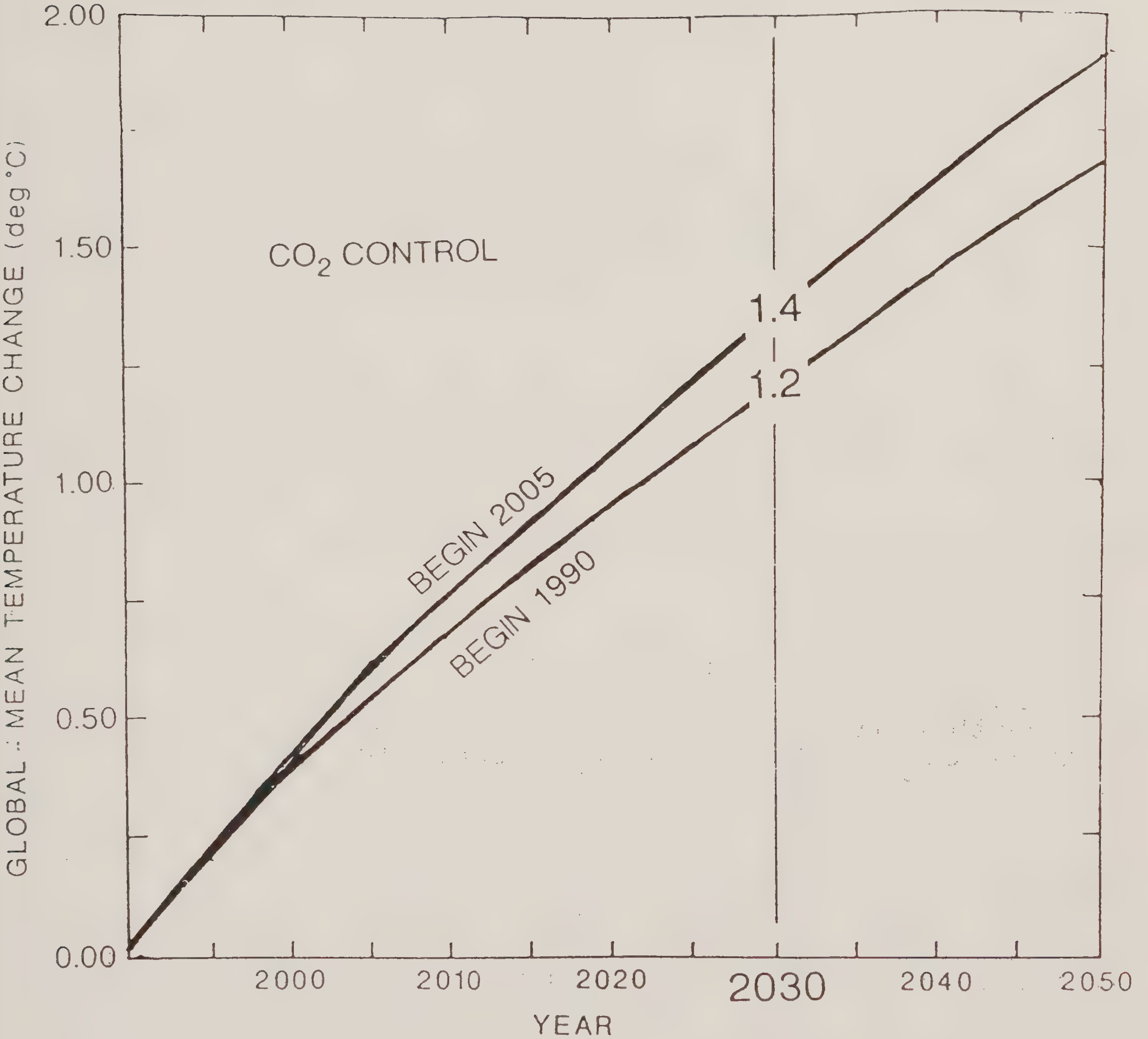

Figure 7: The effects on global warming of delaying a strategy for CO_2 emission reduction.

ENERGY POLICY OPTIONS

By

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Association for the Conservation of Energy

These are strange times we live in: everybody is green, it is only the shade of green which is different. I suspect that future meetings, conferences and papers of the NSCA are going to be important in this new game where everybody is green, because it has become even more important now to differentiate between what is really green, and what is just green gloss. Clearly it is necessary to separate fact from fiction.

In my presentation I want to focus on the question of - in response to scientific knowledge and uncertainty how do we act? Do we take the approach that there is no point in doing anything or do we act now? My view is that we should act now. With that approach, we are at least taking out some form of insurance policy, while we carry out the additional research which is essential.

My starting point is that it is important to take some action - we can argue about the extent of it - but is is important to start. If we look back for past precedence, there is nothing in human experience, nothing we have met so far, whether it be the severe oil shocks of 1973 and 1979 which caused a major economic recession, and caused all sorts of ripples and changes through our economic and energy system or, even disasters such as Chernobyl, serious as that was, which have prepared us for climate change. This is a different order of magnitude, and looking back on past precedence, you might say that it seems impossible that we can solve them. However, I do not accept that view. But I am not under-estimating that it is going to take extraordinary levels of persistence and vision, and leadership of a level that all too frequently is not shown by leaders with their short-term horizon; it is going to require scientific and technological ingenuity, and it is going to take the individual commitment of millions of people.

My purpose therefore is really four-fold: firstly, to identify the role of energy in relation to global warming and greenhouse emissions; secondly, to outline the options available to us to combat the problem; thirdly, to quantify that, as well as give some indication of what those options could deliver, and some of the cost implications; and finally, to suggest appropriate policy measures and levers by which we get there.

I think some former perspective is important. Figure 1 is a very simplified diagram of the carbon cycle, and this is in pre-industrial times, when in effect there was a closed carbon cycle. All the figures are in gigatonnes of carbon per year. If we compare that with where we are now (Figure 2), and you look at what appears to be very minor changes, you can see the role of fossil fuels - 5 gigatonnes of carbon per year - and the contribution from deforestation around 2 gigatonnes per year. These look miniscule in comparison with the normal carbon flows. This is what is disrupting the system however, and our goal therefore must be in the longer term to move towards another closed cycle again.

So how important is energy in this, and what can we do? First of all, we need to look at the activities contributing to global warming (figure 3). Energy contributes just under 60%, in terms of human activities. The CFC figure will clearly change quite quickly through time particularly if a revised Montreal Protocol is agreed soon. Land use modification, agriculture and other industrial activities - including cement production also have an effect. While the chart gives global figures, it is important to note that the fossil fuel contribution varies depending on which part of the world we are talking about (see figure 4).

In the USA it is about 70%, in the rest of the OECD it is much less than that at about 56%. In Eastern Europe fossil fuel production in terms of activities contributes nearly 80%, but in the developing world it is a much lower contribution; agriculture and land use modification are more important to take note of in terms of policy prescriptions. This is one of the themes that I will be developing, namely that global macro trends often hide very important regional and national - and indeed sectors within a country - differences, and it is important to know what those differences really are to identify the optimum solutions.

There has been a lot of scientific and political discussion about bringing down greenhouse gas emissions, and about what is an appropriate target in the same way that we look at CFCs. There is a difference between the scientific limits that are suggested, versus what is practicably possible without disrupting whole countries economies. So far as carbon dioxide is concerned, the Toronto 1988 conference suggested 20% CO_2 reduction from 1988 levels by 2005. It is very important to bear in mind that that is a political target - a short term political target to get us started. In the longer term, a lot of people are suggesting that reductions of carbon dioxide of between 50-80% are going to be required to stabilise climate - this will not stop global warming, but it will at some point in the future stabilise it.

I have recently carried out an assessment of over thirty carbon dioxide scenarios, looking at seven global studies, three regional studies, and twenty national studies, some of

which included more than one scenario. The conclusions are not surprising; under the "business as usual" approach, there are very large increases of carbon dioxide emissions in all of the scenarios (see figure 5). The global study figure is 70-210% by the year 2020, and 46-50% by 2010. The regional studies, essentially Western Europe, and the national studies, showed a range of between 10-60% by 2005-2010. An important thing to note is that most of these studies are taking place in either Eastern Europe or OECD. The individual case studies for the developing countries which I think are crucial to understanding what some of these long term projections of future greenhouse gas emissions might be are not yet available. So basically the "business as usual" would take us in the wrong direction as far as CO2 emissions are concerned.

The scenarios also point out that the technical potential for CO2 reductions is quite large. Most of the studies indicated you could hit that initial Toronto political goal of 20% over the next 15 years. A range of cuts is possible in the other studies: the global studies, for example showed reductions of, 50-70% by the year 2020-2040 (see figure 5).

Technical potential is not necessarily the real world. A study ACE carried out for the World Wide Fund for Nature showed that the pattern was familiar in the UK - about a 20% increase under the "business as usual" scenario over the next fifteen years, and 18-23% reductions under several efficiency scenarios (see Figure 7). Particularly strong in electricity and also transport.

Figure 6 shows the range of future energy scenarios that have been produced for the world, looking through the next 40-50 years. It shows a vast range of figures over several orders of magnitude which does at least give some indication about the importance of value judgements and the assumptions in these modelling exercises, which are critical. I think it is fair to say that the high energy growth scenarios really demonstrate the phenomenon which is known as the "roast the rich scenario". Basically the only way you could actually use the sort of massive increases in energy predicted for the OECD countries, would be to heat people's buildings to about five times current levels, effectively to blood heat level. They fail to take account that there are saturation levels - you cannot drive three or four cars at the same time; once you have got one fridge, do you need two or three? and once you have got reasonable temperatures in houses, do you need to keep on heating it?

So what are the options? the first one is obviously to improve combustion and production efficiency of energy, that is the way we are actually using energy. Secondly, to improve the end-use, that is the point-of-use efficiency, in appliances, lights and so on. Thirdly is a switch to less carbon-intensive fuels, and in this case the one that is often quoted is natural gas. Fourthly, to switch to non-carbon fuels, essentially nuclear and/or renewables.

Finally another way is to increase the carbon sinks, effectively by mass plantations schemes for trees (see figure 7).

Improving Combustion Efficiency

On the combustion side there is considerable potential. Power stations operate at best at 35-38% efficiencies in much of the OECD, and there is a lot that can be done to improve that, both by technology and secondly by fuel switching. On the technology side, you have new power stations, such as atmospheric fluidised bed, pressurised fluidised bed, integrated gas combined cycles, natural gas turbines, and a natural gas combined cycle. All of these provide scope for actually reducing the amount of CO_2 per unit of energy by as much as 30% (see figure 8), and it is important whilst we are still using fossil fuels that we do use those technologies.

Fuel Switching

Looking at fuel switching on the combustion side, on a straight carbon co-efficient level, you have a picture which looks very good for gas, less good for oil, much worse for coal, and for synthetic fuels, particularly coal and oil, it is very bad (see figure 9). Now let me just put a caveat in here. I have stood on many platforms and argued the case that natural gas is an important fuel, as a bridging fuel, to hold down emissions in the shorter term. The major caveat is this: that whilst the carbon co-efficients are clearly lower for gas, for the same level of energy produced, it must be on the basis that the natural gas system is relatively lead-free, because if there are significant leaks - in this case it would be methane - then there may be problems. Methane is a very powerful greenhouse gas, approximately 30 times more powerful molecule per molecule than carbon dioxide. Now, clearly that is mitigated to some extent, because not all of that stays in the atmosphere. But there are also some indirect effects which are not well understood, but may in fact increase the radiative forcing of methane perhaps to 75% of the direct impact of methane leaks. New studies in the United States have been looking at production venting, distribution of transmission, right the way down to local networks, and also the point of use. This included some methane and air monitoring over urban areas to get some indication of whether the leaks that are suggested by the measuring are verified by the monitoring in the air. The studies suggest that the range is between 0.9% and 2.85%, with in one case a utility reporting 6% losses.

Clearly some of that may be under the category of "material unaccounted for" - an accounting loss, rather than a real loss. Without belabouring the point, I would like to be convinced very strongly by the full release of data by British Gas in this country on the testing they carry out, the methodology, and what monitoring is available that they

do run a tight system. Unless we are convinced of that, then even small leaks - and the suggestion is a band of 1-2% leakage - then natural gas may be no better than oil. It is important, therefore, that before we commit that investment that we clear up this concern.

End Use Efficiency

Moving to end-use efficiency in the UK, power stations are extremely important as is transport and domestic buildings with other areas less important. ACE has recently carried out a detailed end-use efficiency assessment of the potential available for CO_2 reductions over the next fifteen years. We found there was potential to save up to 127 million tonnes, which is about 20-23% of total UK emissions (see figure 10). That was on the basis of using technology available now. There is an assumption in three of the five sectors we studied of continuing economic growth of 2.5%; data was not available for the other two sectors.

These are generally cost-effective measures, not things that are going to cost the earth. In all areas there was scope for improving building thermal insulation, improving the thermal efficiency of power stations, changing light bulbs to more efficiency compact fluorescents, more efficient cars, and so on. There was significant scope for cost-effective savings, and that is a pattern which is repeated throughout the OECD. For example, for refrigerators, - around one kw hour is one kilogram of CO_2 and while there was a significant improvement up to 1988, the best available you can buy now uses only a third of the electricity of the average sold in 1988; there are obviously even more advanced machines on top of that (see figure 11). Capital costs are greater though not much, but the running costs are much lower.

Looking at transport, this raises the question of both efficiency and also policy shifts. Transport is an important area because it accounts for about 18-20% of global CO_2 emissions and this is rising in many OECD countries at about 3% or 4% per year.

The only three alternative transport fuels at the moment which actually give significant reductions in CO_2, are hydrogen using non fossil-fuel electricity; electric vehicles - once again this has to be from non-fossil fuel electricity (it is no use having electric vehicles if you are using coal fired power stations) and finally methanol if from biomass (see figure 12). By way of illustration to show how this fact has not been understood by policy makers, under the US Clean Air Act, methanol was being put forward as a front runner to help urban smog problems. In California there is planned to be a significant shift over the next 15-20 years towards methanol because of smog (ozone pollution).

Recent studies show that with regard to CO_2 emissions,

methanol will hardly make any difference at all - a 3% to 8% saving in carbon dioxide emissions at most, by switching the whole system to methanol based on natural gas.

How do these four CO2 reduction options fit together? Conservation both in combustion production, and end use; the switching to natural gas from coal, and the move towards non-carbon based fuels, (essentially nuclear fission and renewables). With regard to non-carbon based fuels, both renewables and nuclear are in a similar position in that in the absence of energy conservation controlling demand, you cannot build enough wind parks and nuclear power reactors to really have a significant impact. One assessment was that you would have to build between 5,000-8000 nuclear power stations - that is one in every one and a half to three days - simply to get rid of coal from the electricity system (see figure 13). Unfortunately you are still using fossil fuels throughout other areas, in cars and industry, and so CO2 emissions would still grow, albeit at a slower rate. The same analysis is true for renewables; without controlling demand you are not going to get very far.

I think the discussion on nuclear power is important. There are two factors, one of which is that nuclear does have environmental impacts; in addition there is a resource implication of how much uranium is available, and, unless you make the switch between fast breeder reactors and plutonium, it is a short term interim option at best. But I will say - and this is a personal view - we have actually tried the nuclear option; we do have some data and we do have some operating experience of how it has performed, and we have invested a lot of money in it over the last thirty years. That is why I would urge, that we give renewables a fair opportunity. I am not saying nuclear does not have a role, but I think the onus has to be on the nuclear industry to respond to the concerns about nuclear waste, proliferation and accidents. If there really is such a thing as a safe reactors, it is up to it - to the industry - to demonstrate that to the public, who are clearly not convinced at the moment. In the longer term the non-carbon based options are really important, because we have got to make that switch to the closed carbon cycle again. But using a "business as usual" scenario of coal, oil, and other fuels, nuclear and so on, and the associated increased CO2 emissions, indicates an increase in CO2 emissions of up to 210% by 2000 which is unacceptable. Using the range of all those options - efficiency, the fuel switching and so on, you can control and reduce emissions, but there is a cost.

The Cost of CO2 Abatement

For OECD countries most of the analysis (figure 14) suggests that the first 20-30% of savings is either at negative cost or very low cost, and the is gets progressively harder and more expensive (see figure 15). For lesser developed countries, it is slightly different; there is a negative cost area, and there is a large area which links issues such

as forests, and use of CFCs with relatively low cost savings, and it is a long spread before there is high costing again (see figure 15).

To put it in perspective, to get that first 5%, we are talking in OECD about 0.4% of GDP and higher start-up costs in Eastern Europe and the rest of the world, 1.1% and 1.5%; This shows that the initial capital outlay is much less than commonly thought, but that the initial start will still leave a gap if we aim to halve CO2 emissions: Going back to the targets we talked about earlier - 50%-70% cuts in CO2, and cuts in other emissions, the cost-effective options will still leave a significant gap, perhaps 25%-30%. I suggest that this figure may be an underestimate because I do not believe market forces will deliver more than 15%-20% of the potential. There are a wide range of barriers, and to illustrate the point, I will mention a few.

Barriers to CO2 Abatement

Assessment in the North West of England showed the reasons why people were not investing in energy efficiency (see figure 16). Reasons, for example, ranged from lack of finance in the public sector and also the private sector, down to simple lack of confidence and, lack of information. Basic things and basic market barriers, which governments and others can do something about.

It is clear there is a big potential for savings. Using the range of policy options, the first 25%-30% is extremely cost-effective but it will not happen by itself. The market, the various signals that are given to customers, and the actual access to capital they may have to be able to make the shift, all mean it will not happen on its own. So we do need significant policy changes in these areas - informational and promotional campaigns, regulations and minimum standards, for things like buildings cars and so on, as well as financial incentives and taxation!

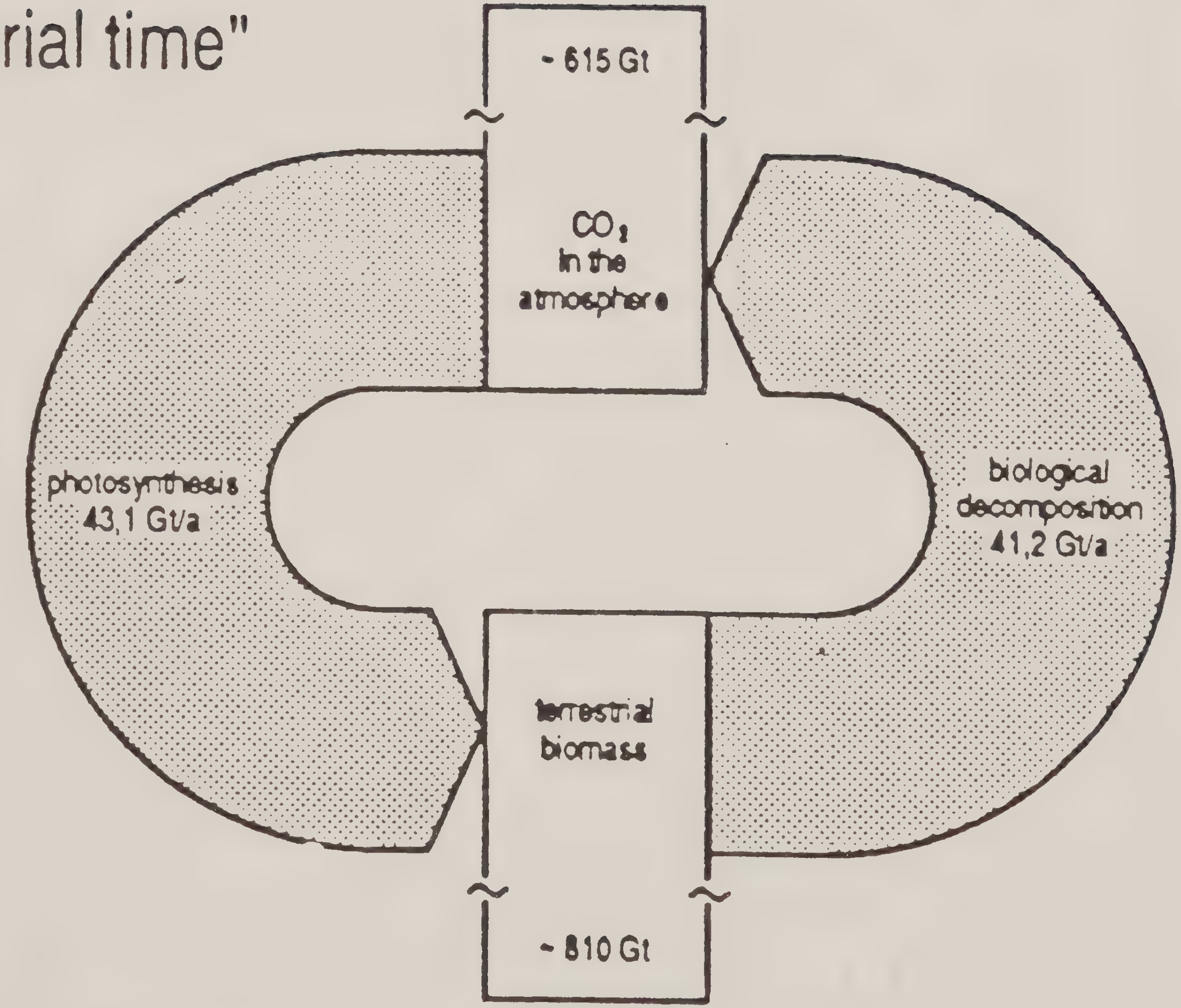
The market can work well, if it is a proper market, and we have heard a lot about the David Pearce report (Blueprint for a Green Economy). Basically what he is trying to do is give the environment a price, to include it in the economic analysis, and that must include the externalities of fossil fuels, and I might say environmental externalities of all options including nuclear and renewables. It is important that we start to include that in our analysis as you will then get a very different picture. A study in West Germany suggested that by including the externalities you would increase the price of electricity from nuclear and coal by between 50%-110%, the implication being that people would respond to that increase with more energy saving. I would suggest that you will need a mixture of incentives and information, as well as minimum standards.

To sum up, I believe there is scope for unilateral action by

countries while the politicians internationally go into one conference after another, and one discussion after another to agree international targets. There is scope given that those first tranches of savings are extremely cost-effective; they do not hurt and they actually help, so the role of unilateral action should not be dismissed. It is important that we break open the log jam and start the process of confidence building. The process towards international solutions which will be difficult - more difficult than ozone and CFCs - and help through that process, the consolidation, the confidence building which might get us there (see figure 17).

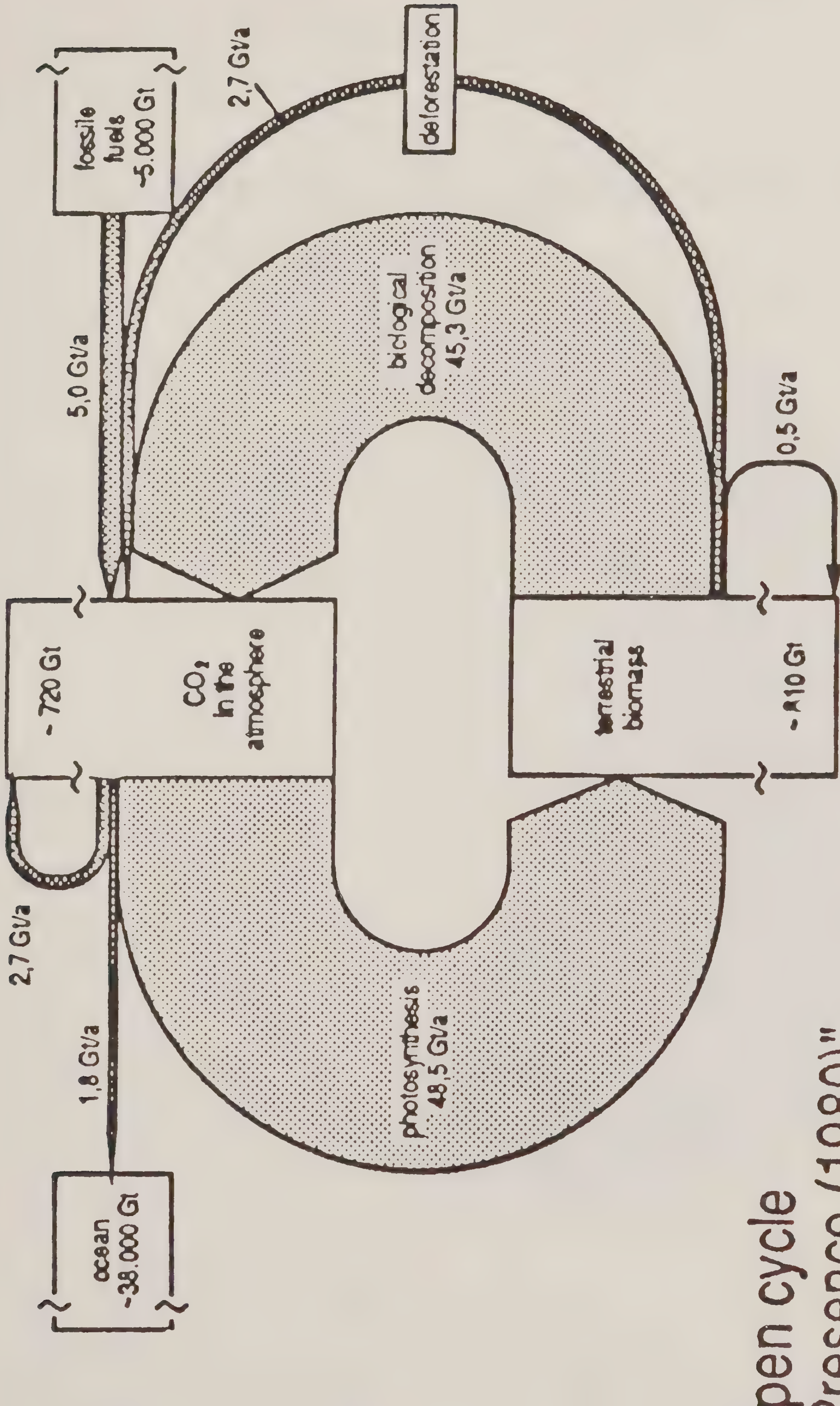
Ultimately we are looking in the longer term for a closed carbon cycle once again but that has to be a longer term goal. I started off by saying that looking at past precedence you would say we are not going to make it, there is nothing in our experience that has prepared us for this. It is very important we start to take action and thus, as Dr. Warrick from the Climate Research Unit has stated, buy time. I am confident that if we can start, we can actually improve on some of the predictions, because the detailed assessment on a country by country basis shows that the potential to bring down fossil fuel use is actually much greater. There remains the key problem of the developing world, the population trends there and what might happen, and that is going to require a new relationship between us and developing countries. My message is a positive one in that we do not have to remain helpless in the face of the planet's most serious environmental threat.

Closed cycle
"Pre-industrial time"



Development of the carbon cycle
Figures according to ESSER 1987
- Mass flows: Gigatons carbon per year
- Reservoirs: Gigatons carbon

Fig. 1



Open cycle
"Presence (1980)"

Development of the carbon cycle
Figures according to ESSER 1987
- Mass flows: Gigatons carbon per year
- Reservoirs: Gigatons carbon

Fig. 2

ACTIVITIES CONTRIBUTING TO GLOBAL WARMING

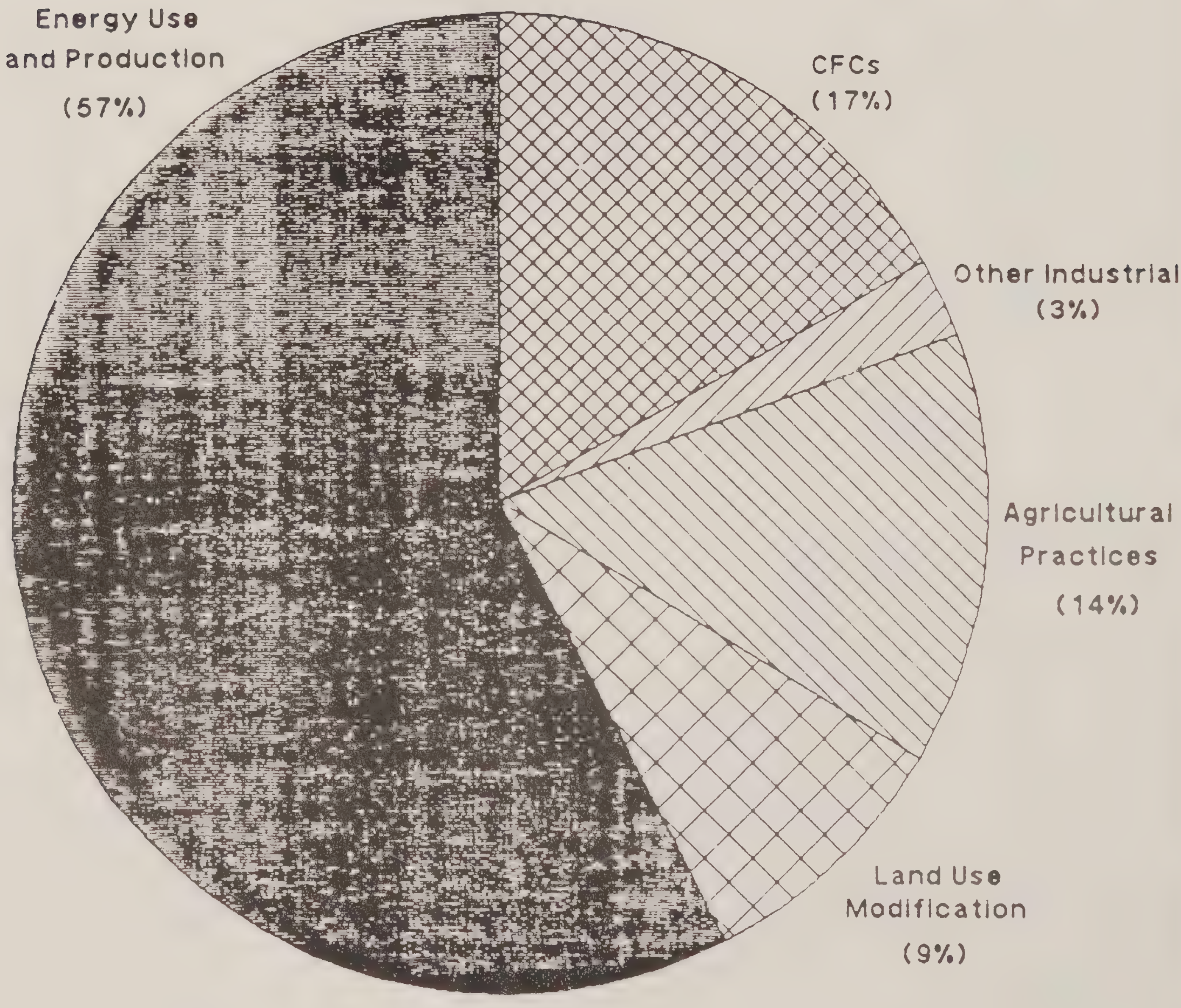


Fig. 3

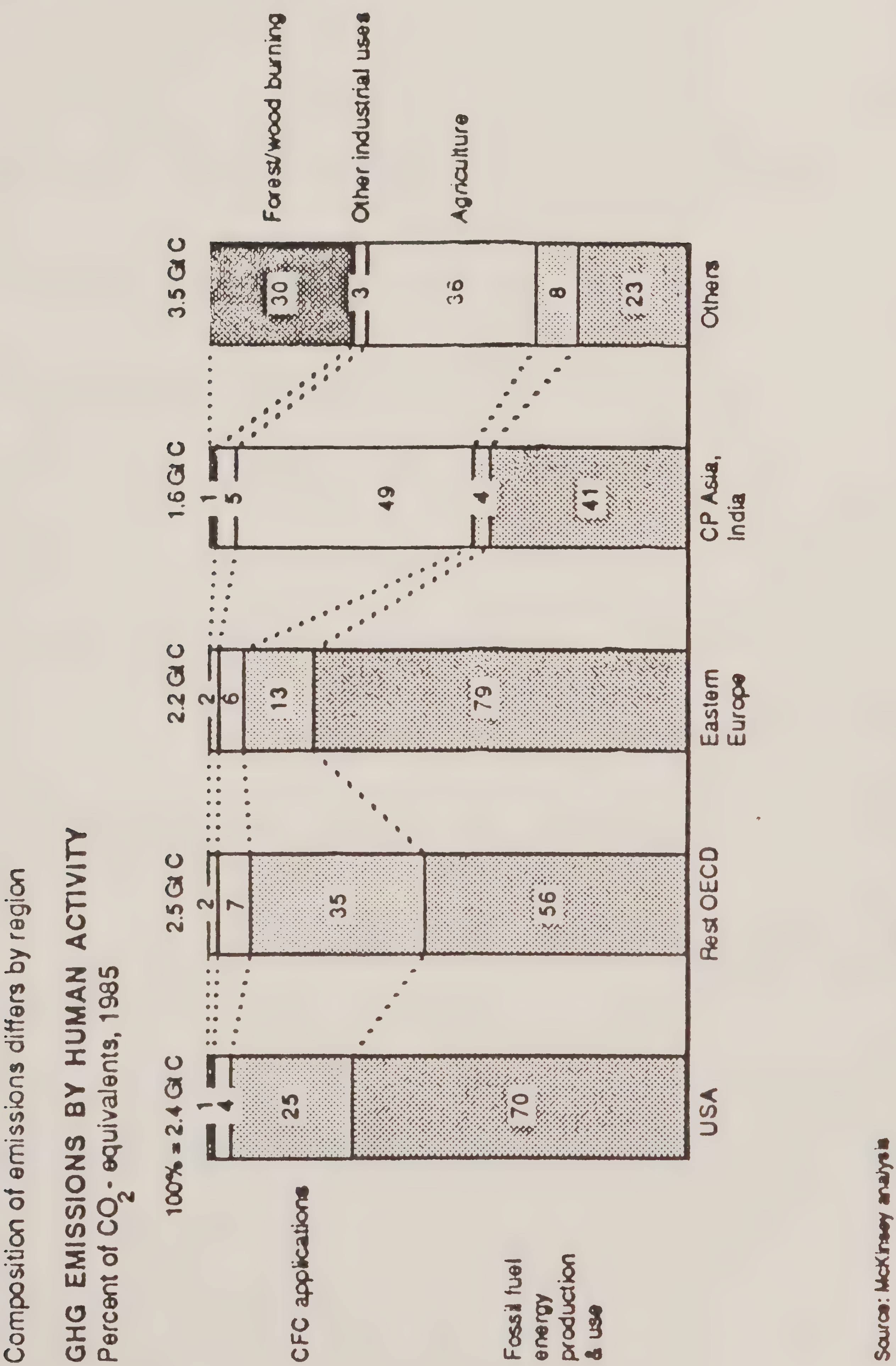

Composition of emissions differs by region
GHG EMISSIONS BY HUMAN ACTIVITY
Percent of CO_2 - equivalents, 1985
100% = 2.4 Gt C
2.5 Gt C
2.2 Gt C
1.6 Gt C
3.5 Gt C
CFC applications
Fossil fuel energy production & use
Forest/wood burning
Other industrial uses
Agriculture
1
4
25
70
2
7
35
56
2
6
13
79
1
5
49
4
41
30
3
36
8
23
USA
Rest OECD
Eastern Europe
CP Asia, India
Others
Source: McKinsey analysis

Fig. 4

AN ASSESSMENT OF MORE THAN 30 CO_2/ENERGY SCENARIOS FOR WWFI

7 GLOBAL STUDIES

3 REGIONAL STUDIES

20 NATIONAL STUDIES (12 nations)

Fig. 5

RESULTS OF ASSESSMENT

'BUSINESS AS USUAL'

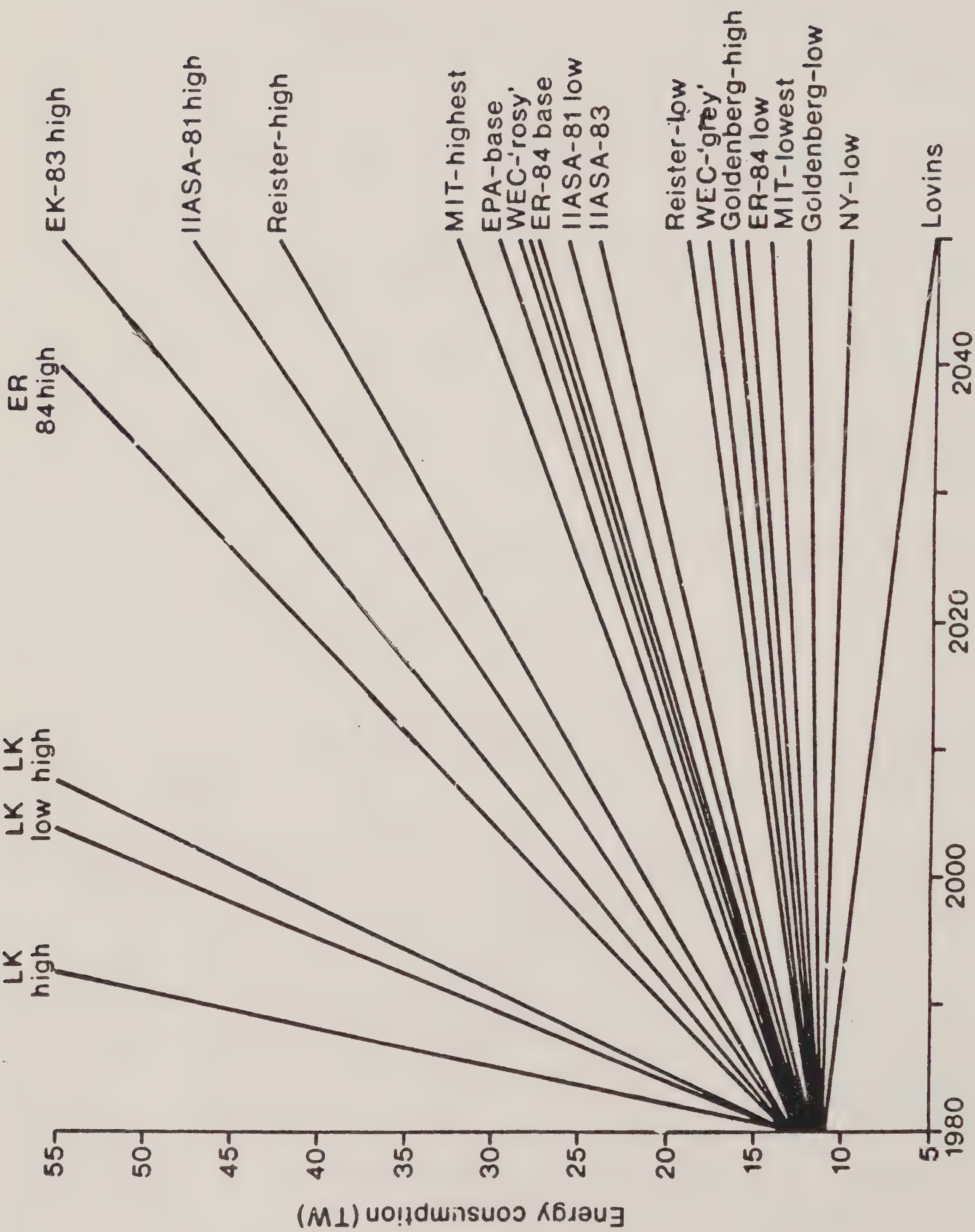
LARGE INCREASES IN CO_2 EMISSIONS

- 70-210% by 2020 in global studies
- 460-50% by 2010 in regional studies
- 10-60% by 2010 in national studies

TECHNICAL POTENTIAL FOR REDUCTIONS

- 13 out of 20 national studies show 20% cuts by 2005 are possible
- cuts of 20% by 2005, and 50-70% by 2020/2040 are possible
- cuts of 16% by 2010 in E.C. study.

Fig. 6



Source: Keepin 1985. Bill Keepin et al.: Future Energy and CO_2 projections.

Fig. 7

ENERGY OPTIONS TO COMBAT GLOBAL WARMING

IMPROVE PRODUCTION/COMBUSTION EFFICIENCY

IMPROVE END-USE EFFICIENCY

SWITCH TO LESS CARBON INTENSIVE FUELS (eg. N. GAS)

SWITCH TO NON-CARBON FUELS (ie. Nuclear fission, renewables)

INCREASE CARBON SINKS (eg. Biomass plantations)

Fig. 8

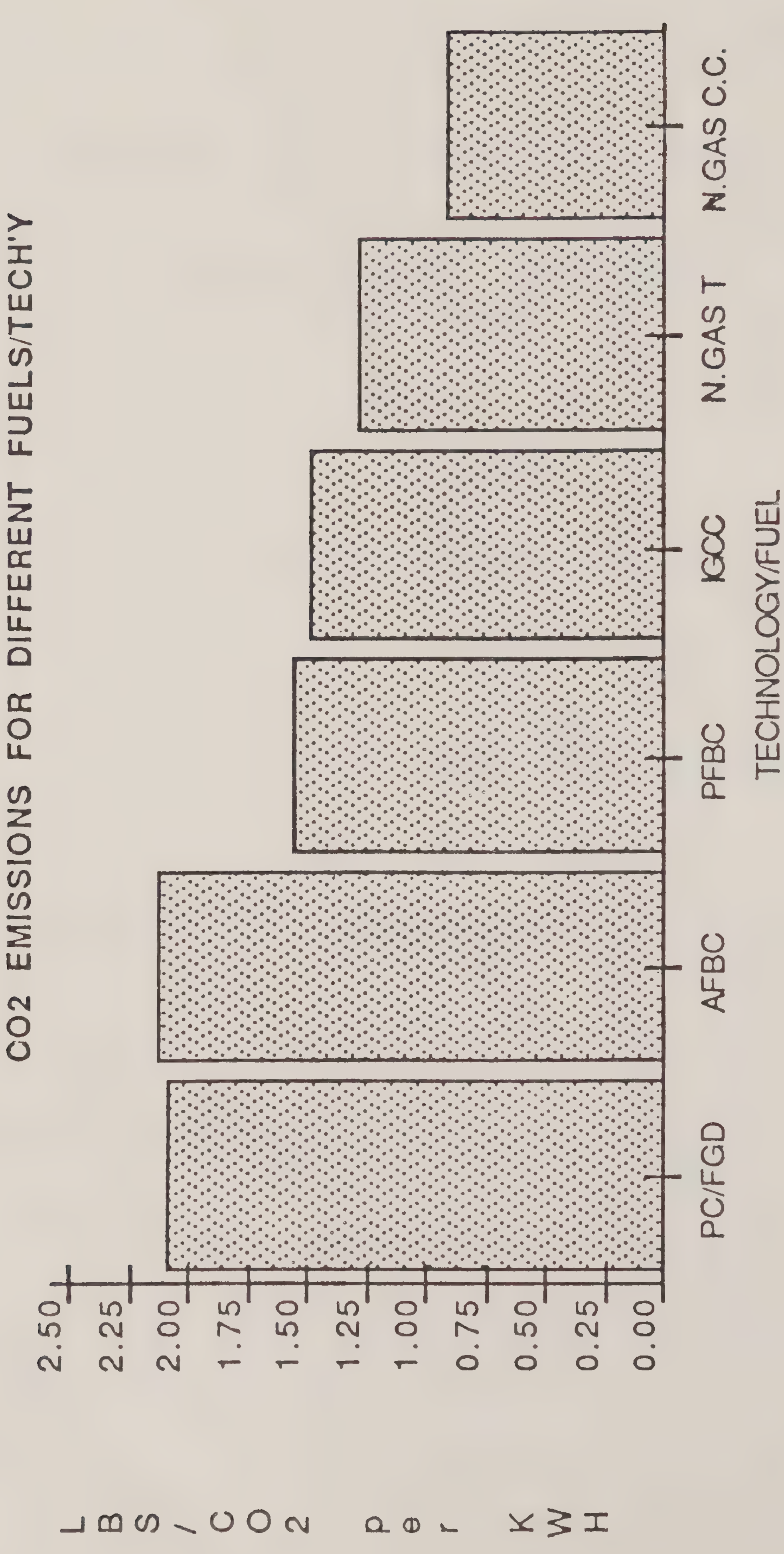

CO2 EMISSIONS FOR DIFFERENT FUELS/TECH'Y
LBS/CO2 per KWH
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
PC/FGD
AFBC
PFBC
IGCC
N.GAS T
N.GAS C.C.
TECHNOLOGY/FUEL

Fig. 9

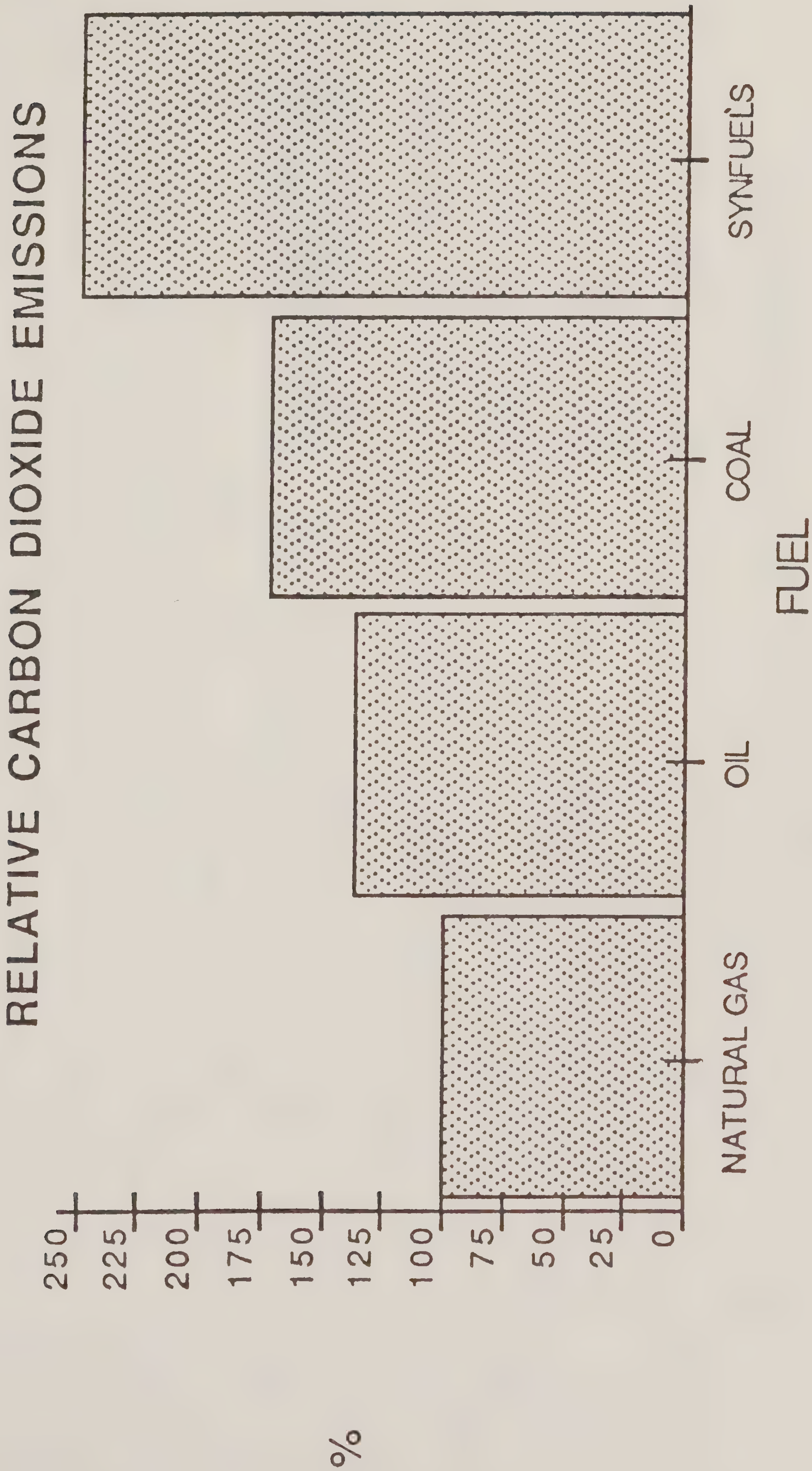

RELATIVE CARBON DIOXIDE EMISSIONS
%
250
225
200
175
150
125
100
75
50
25
0
NATURAL GAS
OIL
COAL
SYNFUELS
FUEL

Fig. 10

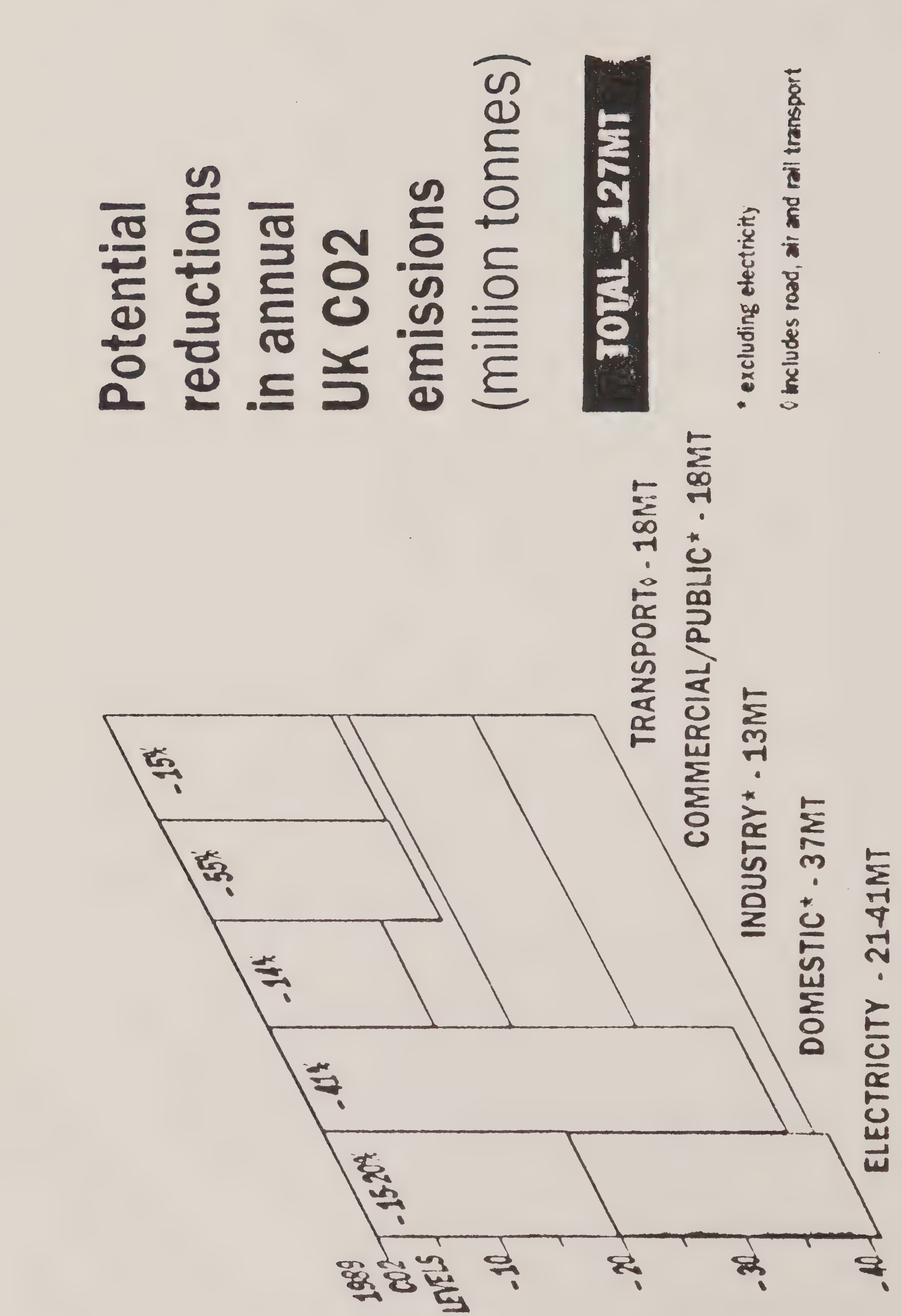
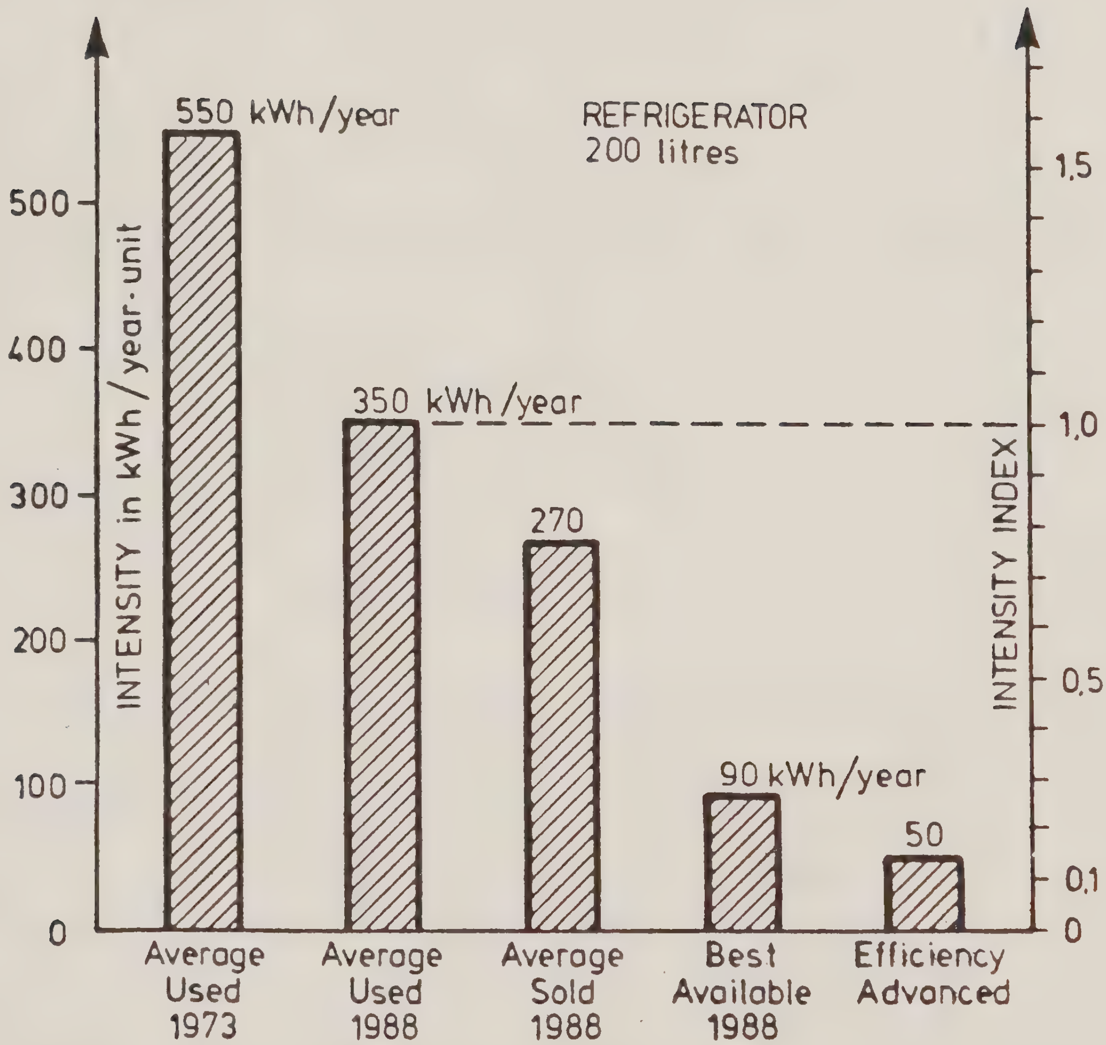
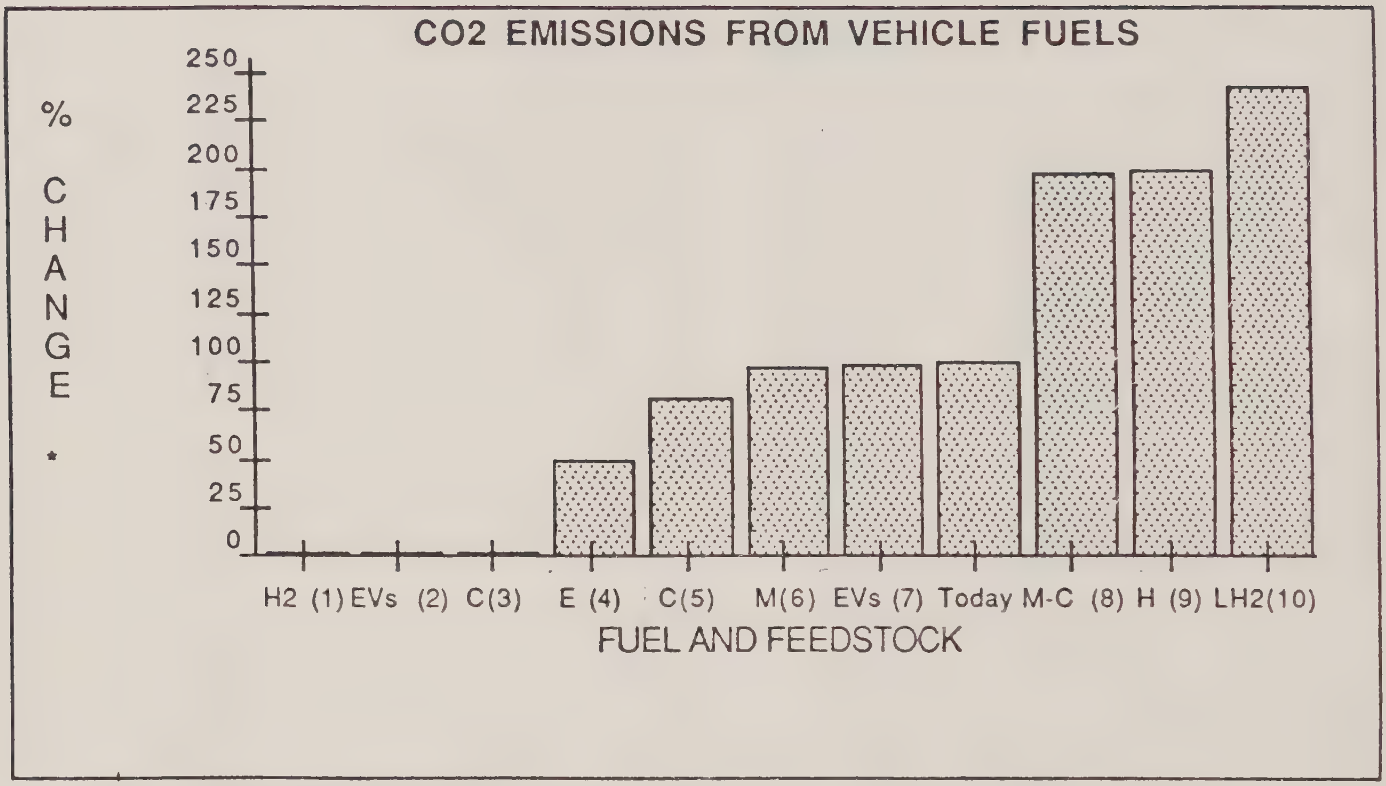

Potential reductions in annual UK CO2 emissions (million tonnes)
TOTAL - 127MT
* excluding electricity
◊ includes road, air and rail transport
TRANSPORT◊ - 18MT
COMMERCIAL/PUBLIC* - 18MT
INDUSTRY* - 13MT
DOMESTIC* - 37MT
ELECTRICITY - 21-41MT
1989 CO2 LEVELS
-10
-20
-30
-40

Fig. 11



Electricity consumption at European standard test condition for various versions of a 200 litre refrigerator with no freezer compartment. The intensity index on the scale to the right illustrates the relative improvements, and it is approximately transferable to other refrigerators as well as to units with a small freezer compartment and to commercial units in shops, etc.

Fig. 12



KEY

(1) Hydrogen from non-fossil (NFF) electricity
(2) Electric Vehicles from NFF electricity
(3) CNG/LNG/methanol from biomass
(4) Doubled vehicle fleet efficiency
(5) CNG from natural gas
(6) Methanol from natural gas
(7) Electric Vehicles from current power mix (US)
(8) Methanol from coal
(9) Hydride from coal
(10) Liquid hydrogen from coal
TODAY = petrol and diesel from crude oil

Fig. 13

NUCLEAR POWER - A SOLUTION TO GLOBAL WARMING?

MEDIUM ENERGY GROWTH SCENARIO

BY 2025

5200 LARGE NUCLEAR PLANTS (18-FOLD INCREASE IN CURRENT CAPACITY).

A NEW PLANT EVERY 2.5 DAYS.

$151 BILLION PER YEAR.

OUTCOME CO2 EM.SSIONS STILL 6% HIGHER.

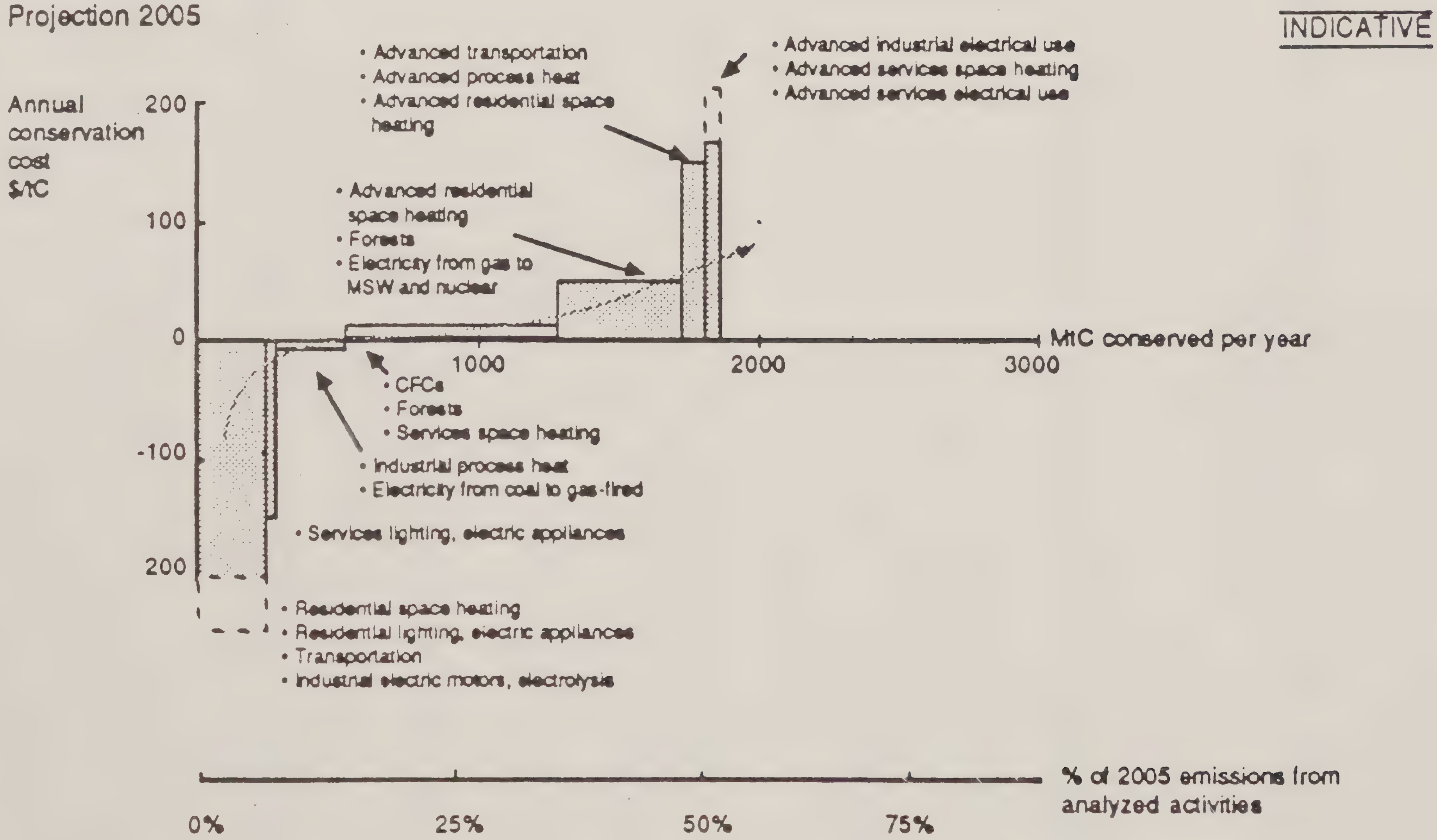
Keeping & Kats (1988)

Fig.13

Efficient measures may generate approximately 30 percent emission reduction in OECD

COST CURVE OECD

Projection 2005



Note: Based on available research material

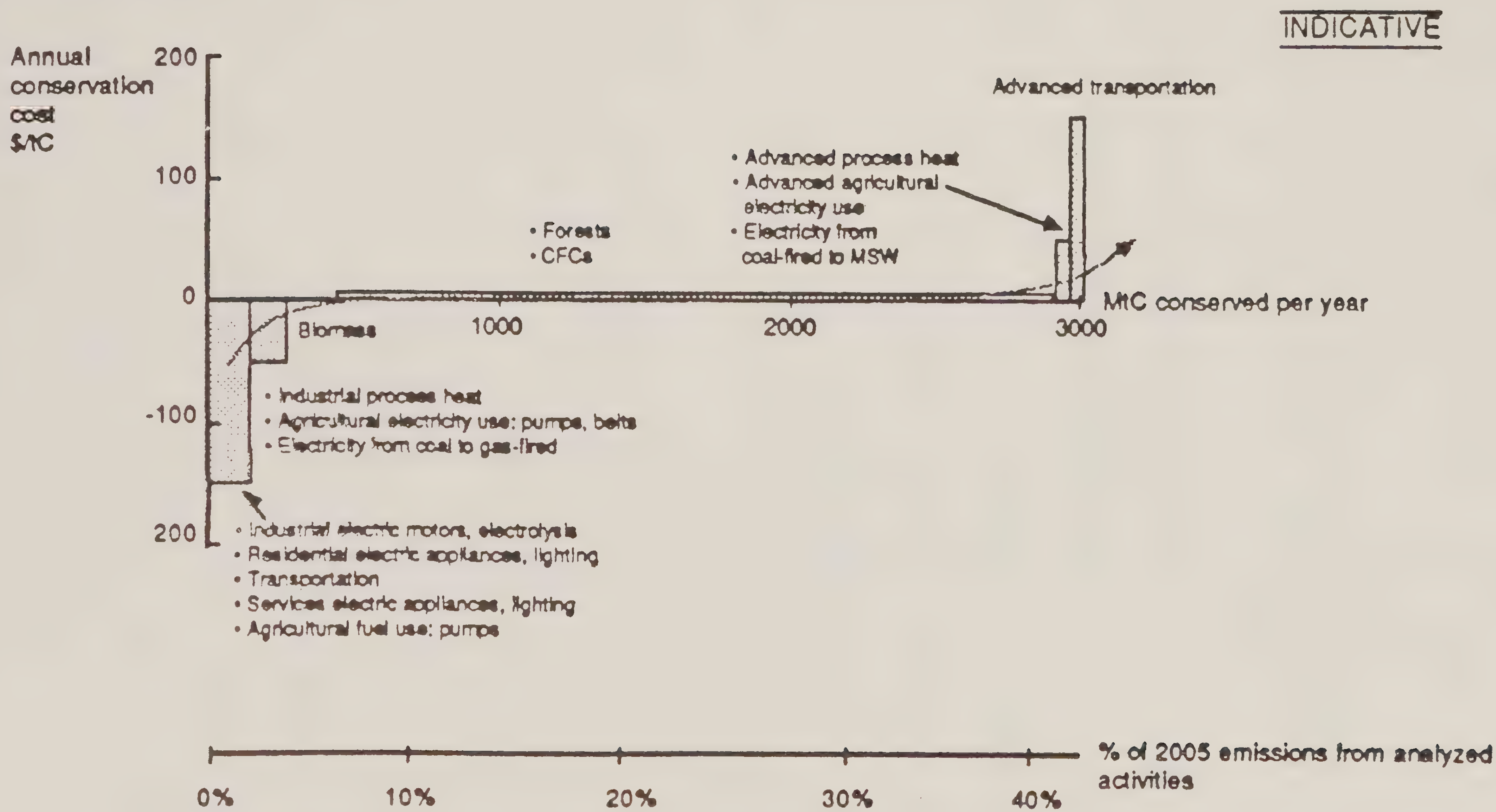
Source: International energy consultants; McKinsey analysis

Fig. 14

...and elsewhere

COST CURVE REST OF WORLD

Projection 2005

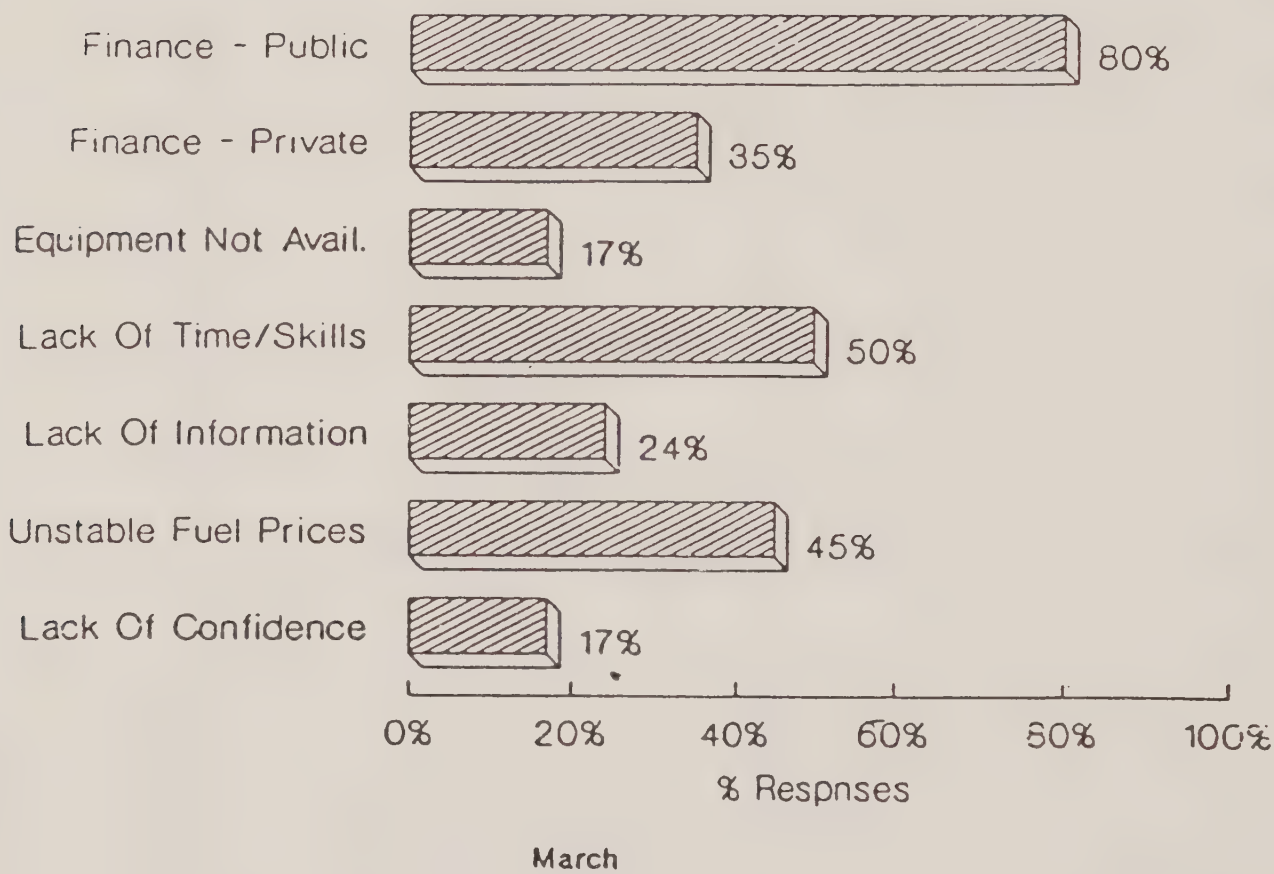


Note: Based on available research material

Source: International energy consultants; McKinsey analysis

Fig. 15

PERCEIVED BARRIERS TO IMPLEMENTING FURTHER ENERGY SAVING MEASURES



Source: March Consulting Group

Energy Study of the North West Region of the U.K.

Fig. 16

Framework convention should recognize different nature of two phases

TWO-PHASE APPROACH

Phase	1. Unilateral action	2. International solution	Consolidation
Objective	• Effective unilateral progress • Success formula for international cooperation	• Efficient multilateral solution	• Control
Focal points	• Infrastructure • Domestic measures • Reinforced cooperation - Forest management - CFC funding • Protocol negotiation	• Target optimization • Domestic measures • International action funding, including - Fossil fuel use - Agriculture	• Monitoring of climate, concentrations • Corrective balancing of emissions/absorption
International funds flow	• Limited • Existing channels	• Large • Clearinghouse	• ?

Fig. 17

VEHICLES EMISSIONS CONTROLS - SITUATIONS REPORT

PROSPECTS FOR ENGINE DESIGN AND FUELS TECHNOLOGY

By

Edward Betts
Esso Research Centre

Introduction

This presentation reviews some key current and future developments in diesel and gasoline fuels and vehicles and their impact on improving exhaust emissions.

Comparison of Diesel and Gasoline Exhaust Emissions

In order to gain a perspective on exhaust emissions it is instructive to compare the relative tailpipe emissions of diesel cars and gasoline cars, with and without catalysts. This has been investigated for a range of passenger cars (Ref. 1). Three different driving cycles were used, all showed the same general trend. Figures quoted here are for the USA FTP driving cycle.

For Hydrocarbons, diesel cars have approximately the same level of tailpipe emissions as gasoline cars with catalysts, typically 0.3 g/mile. This is a significant improvement on non-catalyst gasoline cars which emit around 3 g/mile.

A similar position applies for Carbon Monoxide where diesel cars and catalyst gasoline cars typically emit around 1 to 3 g/mile compared to non catalyst car emissions in the range 13 to 32 g/mile.

Diesel engine emissions of Nitrogen Oxides, at approximately 1 g/mile, are higher than catalyst gasoline cars (which were typically 0.1 to 0.4 g/mile) but much lower than the 3 to 7 g/mile level for non catalyst gasoline cars.

Particulate emissions are very low for gasoline cars, around 20 mg/mile for non catalyst vehicles and approximately 6 mg/mile for catalyst cars. In contrast diesel car particulate emissions were much higher ranging from 188 to 658 mg/mile for different vehicles.

Because of the concern over diesel particulates, very low emission standards have been legislated in the USA and rather less stringent levels are being proposed for Europe.

Diesel Particulate Reduction

The key to reducing diesel particulates lies in the engine design to achieve more complete combustion. Figure 1 illustrates the approximate reductions in particulates which can be achieved by increasing levels of engine sophistication on heavy duty engines. Other engine developments, eg reduction of nozzle sac volumes and increased injection pressures, also make dramatic reductions in particulate levels.

Emissions standards currently being discussed for Europe can probably be achieved at the "Electronic Control" level of development while targets proposed for the USA may require particulate traps for some engines.

Diesel Particulate Traps

One type of particulate trap or filter being developed consists of a ceramic honeycomb in which alternative ends of the passages are sealed. Exhaust gases flow through the porous walls of the passages and the soot particles are filtered out. As the particulates collect, the exhaust back pressure is increased, and so the trap needs to be provided with a means of periodically burning-off the particulates. This can be arranged by supplying extra heat to the filter or by using a catalyst coating which reduces the particulate ignition temperature.

Indirect and Direct Injection Diesel Engines

Until recently all passenger car diesel engines were of the indirect injection type. In this type of engine the fuel is injected into a swirl chamber where the combustion starts. The burning gases are then forced through a narrow passage into the combustion chamber. Indirect injection engines have advantages of relative quietness, easier control of combustion and so low exhaust emissions; but they suffer from high fuel consumption due to the energy losses in forcing the combusting gases from the swirl chamber to the combustion chamber.

Heavy duty truck engines use direct injection diesel engines in which the fuel is injected straight into the combustion chamber. In this application fuel economy and power is more important than quietness and smoothness. However, motor manufacturers are overcoming the difficulties of making the direct injection engine acceptable for passenger cars. A very successful example is the ARG Montego Turbo where the use of a Prima direct injection engine has enabled 100 mph and 100 mpg performance to be advertised.

Although this review is of necessity brief and incomplete it serves to illustrate the extensive effort ongoing to improve emissions and efficiency of diesel vehicles. Most of the technology is well known and available on many vehicles

while particulate traps are under active development and field trials to meet future standards.

Gasoline Technology

The major recent change in the UK has been the introduction of unleaded gasoline. Esso was the first petroleum company to launch this in the UK, back in 1986, well ahead of any legislative requirement.

Many cars designed to operate on 97 octane 4-star gasoline require a small engine adjustment before they can use the 95 octane 'Eurograde' unleaded gasoline. But, some high performance cars must have the higher octane only available from leaded 4-star gasoline. To meet the needs of these motorists, and to allow customers to change to unleaded gasoline without the need for an engine adjustment, Esso introduced a 98 octane unleaded gasoline nationwide in July 1989 - Esso Super Plus Unleaded. So now nearly all cars can use unleaded. A few cars with old technology valve metallurgy still do need some 4-star leaded gasoline. Lists are available at all Esso service stations detailing the appropriate gasoline for each car model.

Exhaust Catalysts

While unleaded gasoline is a major advance in reducing lead in the environment the real benefit is the potential to use catalysts to make dramatic reductions in exhaust pollutants. Catalyst cars need unleaded gasoline because lead poisons the catalyst. To avoid misfuelling, catalyst cars have a narrow filler pipe which is only large enough for the small diameter nozzle used on unleaded gasoline pumps. At present only a handful of cars are on sale in the UK with catalysts as standard, but this will now increase rapidly, and make a major contribution to cleaner air, as European legislation comes into force.

Lean Burn Engines

New exhaust emission standards have recently been proposed which would appear to be difficult to meet with current lean-burn technology. Hence the catalyst route is likely to be adopted by the majority of future cars. The politics of lean-burn versus catalysts, and changes in legislative limits is the subject of another paper to this meeting and will not be discussed further here.

Evaporative Emissions

Man-made emissions of Volatile Organic Compounds (VOC) amount to some 10 million ton/year across Europe. The largest source (40% of the total) comes from solvents such as paint drying with the other major area being gasoline vehicles. Petroleum refining and distribution accounts for around 5% of the total and this is being reduced by a variety of improvements including "bottom loading" and Stage

I systems which capture vapours displaced during refilling of service station tanks.

As shown in Figure 2, the bulk of the VOC from cars comes from the exhaust (25% of the total). This source will reduce as the use of catalysts becomes more widespread. Another 10% comes from evaporative emissions. These consist of Hot Soak Losses which occur when fuel evaporates from carburettors after the car has been driven; Diurnal Losses which are due to "tank breathing" as the temperature varies throughout the day; and Running Losses which occur while the car is being driven. The smallest source of VOC, less than 2%, comes from refuelling which displaces vapours in the vehicle's tank.

The most effective way of reducing VOC emissions is to tackle the largest source, and exhaust catalysts will produce an improvement. Figure 2 lists some control options for dealing with evaporative emissions.

One option which has been investigated is to reduce the Reid Vapour Pressure (RVP) of gasoline during the hot summer months. Gasoline vapour pressure is optimised seasonally to provide good driveability performance. Studies have shown that RVP reductions can provide very little environmental benefit while being very expensive to produce.

Another route being studied is known as Stage II refuelling. This only addresses the smallest VOC emission and so has a limited benefit while requiring a massive $2450 million capital investment across Europe.

The most promising route, and the one which is being adopted, is to capture evaporative emissions in a small carbon canister. This is well developed technology which has been a standard fitment in cars sold in USA and Japan for many years.

In cars equipped with carbon canisters, vents from the fuel system are linked to a container filled with activated charcoal. Gasoline vapours are adsorbed by the charcoal and prevented from escaping to the atmosphere. When the car is driven, air is drawn through the bed of charcoal and the gasoline vapours are purged into the engine inlet manifold and combusted as normal. The carbon canister then has capacity to adsorb further vapours when the car is next parked. Experience in USA and Japan shows that well designed canisters operate throughout the life of the vehicle without the need for maintenance. Small carbon canisters are the most cost effective solution for evaporative emissions.

Finally, there is a very exciting development known as the "on-board" refuelling system which uses an enlarged carbon canister to capture not only evaporative emissions but refuelling losses as well.

On-Board Refuelling Control

The on-board system works on the same well proven principle used by small carbon canisters. The key differences are the use of a larger bore hose (typically 15mm) from the fuel tanks to the carbon canister and an enlarged canister (typically 3 to 5 litres compared to around 1.5 litres needed for small carbon canisters). These enhancements allow the vapours displaced when the fuel tank is refuelled to be adsorbed in the canister and later purged back into the engine.

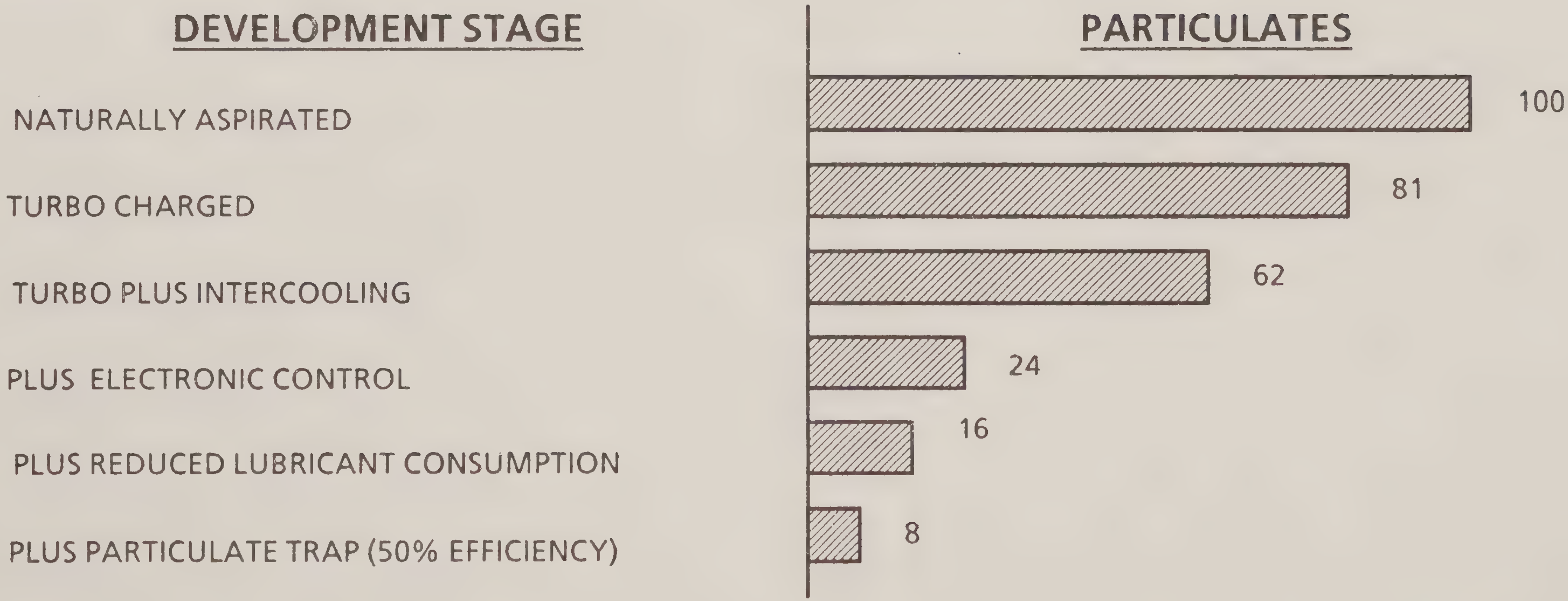
The method has been very successfully demonstrated and extensively tested on two European cars achieving over 97% control of refuelling losses.

Coupled with the introduction of unleaded gasoline and the use of exhaust catalysts, the on-board carbon canister system offers an environmentally efficient and cost effective route to producing clean future vehicles.

References

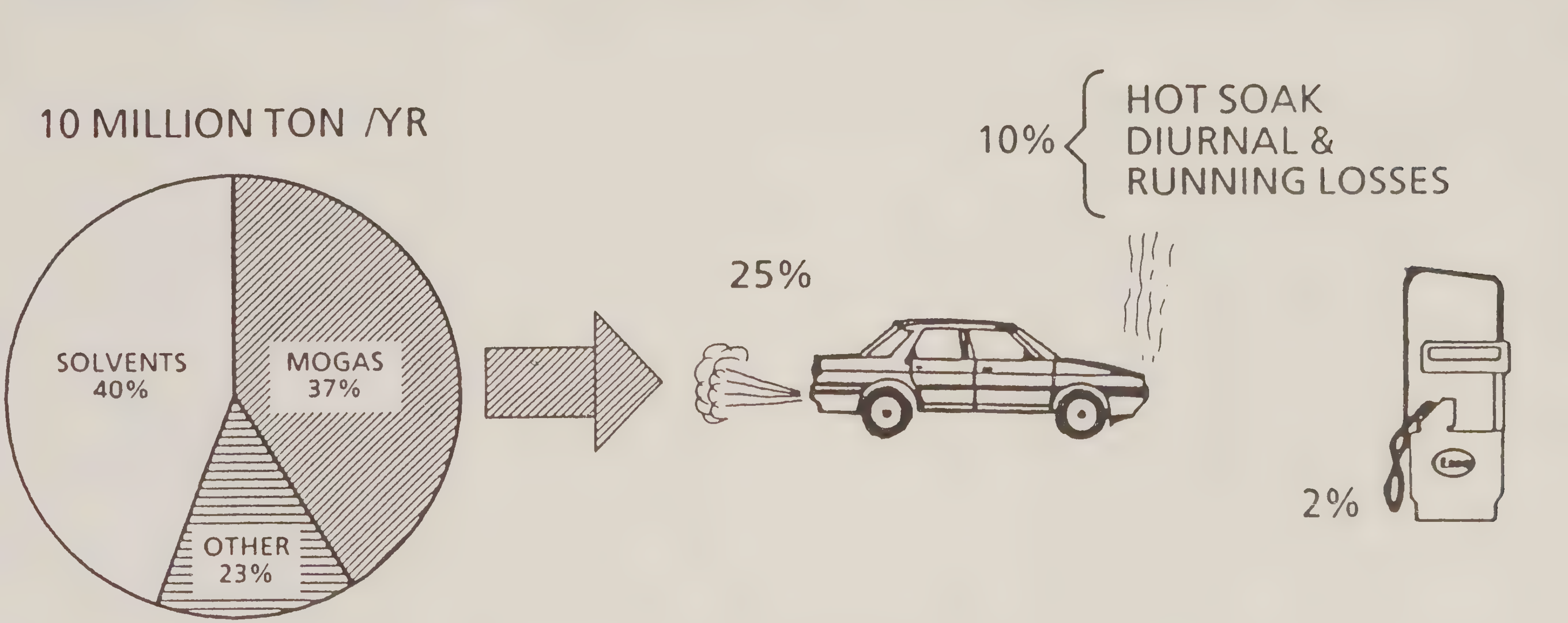
1. Unregulated Motor Vehicle Exhuast Gas Components, Volkswagen AG, Wolfsburg March 1989.

RELATIVE EFFECT OF DIESEL ENGINE TECHNOLOGY ON PARTICULATE EMISSIONS



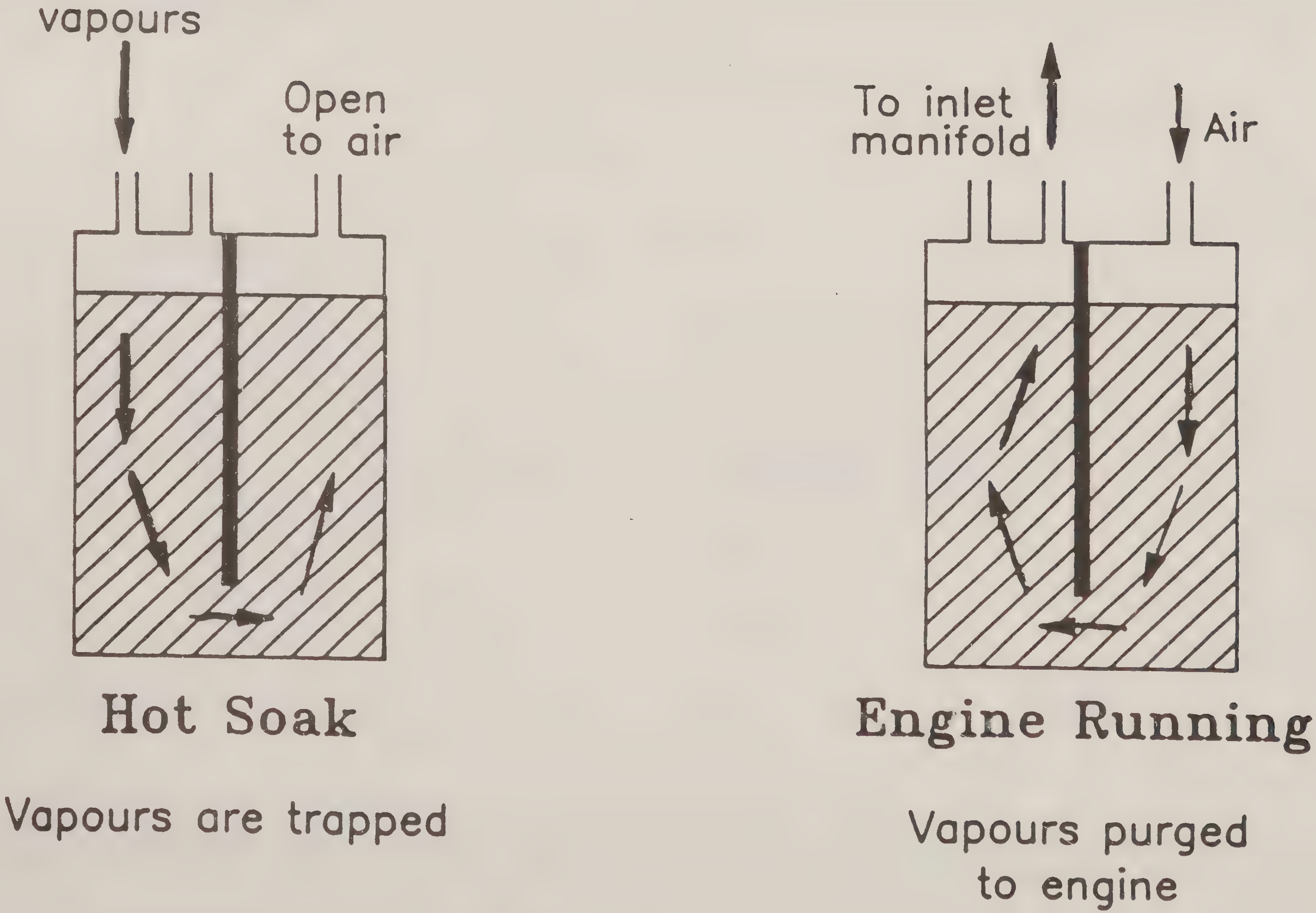
OTHER MEASURES INCLUDE COMBUSTION CHAMBER MODIFICATIONS, REDUCED NOZZLE SAC VOLUMES AND H.P. INJECTION

EUROPEAN VOLATILE ORGANIC COMPOUND (VOC) EMISSIONS



EVAPORATIVE CONTROL OPTIONS	COST	BENEFIT M. TONNE VOC
• SUMMER RVP REDUCTION 60 KPA	\$500M/YR	0.1
• STAGE II REFUELLING	\$2450 M	0.16
• SMALL CARBON CANISTERS	\$10-50 / CAR	0.9
• LARGE CARBON CANISTERS	\$20-80 / CAR	1.1

How A Carbon Canister Works



EVOLVING EUROPEAN LEGISLATION: THE DEMISE OF LEAN-BURN AND THE POLLUTER PAYS PRINCIPLE

By

Dr Sonja Boehmer-Christiansen
University of Sussex
Science Policy Research Unit

I would like to express my thanks to the Anglo-German Foundation which is supporting a two year research project on the regulation of vehicle emissions in Britain and Germany. The project is undertaken jointly by SPRU and the Wissenschaftszentrum Berlin (WZB) and has already involved a large number of people from industry, government and environmental organisations in both countries, as well as my colleagues at SPRU and WZB, who have given freely of their time and expertise to make this research possible. I would like to thank them all, but stress that any opinions expressed, or errors made, are entirely my own.

Introduction

This paper summarises recent European Community regulations of major importance to clean air and speculates why it is taking so long to reach agreement. The debate in Britain and Europe has been an extremely complex one of changing and intertwining implicit motives as well as explicit justifications, which have impinged on environmental policy from the realms of commercial competition, institutional commitment, industrial protection as well as technology choice.

Only an imperfect overview based primarily on an Anglo-German comparison is possible. It is my view that the pursuit of all of these goals has now produced an outcome with very few institutional losers, but which will significantly increase the cost of motoring and the amount of energy consumed by the private transport sector. This is not in my view a genuinely green solution, although potentially a positive one for air quality.

This outcome has been achieved by the demise of the leanburn engine and the temporary relaxation of a major environmental principle, namely that the polluter should pay (PPP) in favour of what the Germans call the Community-Bears-The-Burden Principle. Both the demise of leanburn and of the PPP were absolutely essential for agreement being reached, the first for technical reasons and the second because of political considerations. As a political scientist I must consider both equally rational.

Two questions thus underly my paper. First, why did the British car industry and the British Government resist 'world best practice' for emission abatement for so long? Second, how did the German Government manage to break the European car industry's initial consensus in favour of a 'European solution', lose the battle in 1985 and yet emerge, it would seem, victorious in 1989?

The Argument

The principle and potential efficacy of catalytic conversion of exhaust gases has been known since the 1930s (1). It could have been adopted in Europe in the mid-1980s. By resisting this, Britain assisted in postponing the introduction of fully regulated threeway catalytic conversion of exhaust gases for another decade and more. It rejected the adoption of a technology already implemented in North America, Japan, Korea, Scandinavia, Austria, Switzerland and Australia.

The very brief answer to the first question is that the industry did not want it, that government did not think it necessary and its non-governmental advisors, including the NSCA, did not disagree with this view until very recently. The House of Lords Select Committee on the European Communities, however, chaired by Lord Nathan, warned against continuing on the leanburn path in 1984 (2).

The German Government took a very different view. It became the main proponent for the catalytic solution in the European Community, taking Japan, the USA and Sweden as examples. It was also advised very differently, and then decided to do battle against its own car industry, something which was much easier to do in Germany than Britain. According to German sources, the battle for truly clean vehicles (including heavy vehicles, aeroplanes) and the fuel they need, is by no means over.

I shall deal with these two questions by looking first briefly at the arguments behind the technology choice debate, then briefly describe the regulatory history for gaseous emissions from passenger cars. This will form the background to a short summary of what I understand to have been the motives behind British policy and of the actions taken by the German Government to encourage the catalytic technology at home and within the EC. Since the outcome of the entire regulatory debate so far can only be understood in the wider European context. This will be addressed in the final section of this paper.

THE POLICY BACKGROUND

Leanburn engines

The leanburn engine has been hailed as the British technology for many years by two major British companies and

the Government. Its virtues were to be the combination of much improved energy efficiency due to the combustion of very lean mixtures of gasoline and air (above 20 parts of air to one part of fuel), and its adequacy in terms of emission abatement (3). The regulated pollutants are carbon monoxide (CO), hydrocarbon (HC) and nitrogen oxides (NOx), a mixture of several oxides of nitrogen. The Germans rejected the British argument in the early 1980s because they doubted this adequacy and believed that the very leanburn clean engine, if it could be designed for ordinary cars, was still such a long way off that Government could not wait. In Britain, leanburn was intended as a major commercial breakthrough, at least in the small and medium-sized car market.

Engineers describe those leanburn engines currently on the road (ratio 18 to 1) not as truly leanburn, but as high compression fastburn engines. These engines have one major drawback, for best performance and at higher speeds, even when combined with cheaper oxidation or open loop catalysts, they create too much nitrogen oxide, the industry admits, to comply with the standards recently agreed in Brussels.

Final engineering requirements will not become clear, however, until the values for the new European test cycle combining an urban and a high-speed extra-urban driving cycle are agreed at the political level In this area arguments continue because the real decisions about how much is measured, how, when and under what conditions, are made at this level. The quantity of emissions actually measured during such a test depends on the preparation of the car for the test, the temperature of the engine, and the driving conditions (speed, load) to which the car is subjected. The Germans want to adopt the American Federal Test Cycle, which Sweden and Switzerland adopted in 1976 and 1986.

The standards which had been negotiated and bargained over since 1982 (see below) are just beginning to come into force for cars with large engines, but are measured on the basis of the 'old' European urban test cycle. This significantly underestimates NOx emissions under real driving conditions. These 1985 European standards allowed small cars to be much 'dirtier' than medium sized ones, with only engines over 2 litres requiring full catalytic conversion. They were an invitation to manufacturers of leanburn engines to capture the market for small and medium-sized cars.

There is no single leanburn engine, rather leanburn is a process which has made many European engines more fuel efficient throughout the 1970s. Figure 1 illustrates the effect this has had on nitrogen oxides emissions according to advice given to the German Government by its Environment Office in the early 1980s.

Catalysts

The Federal Republic has called for the adoption of fully

Table 1. The Evolution of European Passenger Car Emission Standards
(EEC type approval and without timetables)

Regulated pollutant	CO	HC	NOx	Comments
	(	in gms per test	)	
1976 ECE 15-02	80	6.8	10	no observable improvement
1979 ECE 15-03	65	6	8.5	in air quality
1984 ECE 15-04*	58	———19———		OK for leanburn
1984 EC Commission proposal, but stage II 'US equivalent'	45	15	6	threat to large HCLB*
1985 Luxembourg Agreement/Compromise (by engine size)				
> 2 litre	25	6.5	3.5	3 way catalysis only
1.4 - 2 litre	30	———8———		leanburn + ox.cat.
< 1.4 litre stage I	45	15	6	OK for leanburn
1988 Small Car Agreement (rejected later)	30	———8———		uncertain
1989 Small Car Agreement	19	———5———		3 way catalysis only?

1989 Council Promise: all cars to comply with the 19:5 standards by 1990 measured with the addition of a high speed component to the test cycle.

* cf. 1978/1981 German proposal to ECE (in g/test)

Weight of vehicle (kg)	CO	HC and NOx
< 1250	30	10
1250 - 1700	36	10
1700 - 2150	42	10
> 2150	48	10

nb A 20% reduction in emission limits will lead to a ten per cent reduction in real emissions five years later.

regulated threeway catalytic converters (ie those which deal with CO, NOx and HC simultaneously) irrespective of vehicle weight or engine size since 1983. Catalytic conversion works on the stoichiometric principle. This requires that the fuel to air mixture is held constant at a certain ratio (14.7 parts of air to 1 part of gasoline) so that complete combustion may take place. For this to happen very quickly (as it must in a working engine), the presence of precious metal catalysts (platinum for CO, rhodium for NOx, palladium for HC), is essential.

In theory all the gases present will then react with each other so that 'only' water vapour, carbon dioxide and nitrogen will leave the tail pipe. The catalysts cover a ceramic honeycomb structure coated with a spongy material and placed inside a metal 'can' which is fitted into the exhaust system. Modern converters are credited with over 90% effectiveness, declining over time to 50%, for all three regulated pollutants, but are still least efficient for NOx. Even catalytic converters cannot reduce all three pollutants to zero. They need a certain temperature to 'light up', they can fail, they can be tampered with, they are easily poisoned, especially by leaded petrol. To remain effective catalysts would need regular inspection and the electronic system which continually adjusts the air-fuel ratio, would have to be well maintained.

Import dependence

There are many different types of converters, but the fully regulated (closed loop) threeway one is the most effective, and the most expensive because of its need for electronic components. It tends to make car companies without their own suppliers dependent on the German firm Bosch. The precious metals are imported from South Africa and the USSR.

Loss of fuel efficiency

The 'extra' costs arising from this abatement technology are not primarily the converter, but the electronic sensors feeding information back to the fuel injection systems which then ensure that the air/fuel mixture remains correct and the fuel is perfectly mixed as much and as often as driving conditions will permit. Catalysts can achieve low NOx values, which are not highly sensitive to the speed at which the car is travelling or its load. However, because engines working with threeway catalysts cannot burn lean, they use more fuel, all else being equal (3). Estimates here depend on the basis of comparison, but the figures I have come across range from 20% to 2% better fuel efficiency of leanburn over whatever the measurer considered to be an equivalent engine.

Demand Creation

The most recent negotiations have also led to the legitimacy (within the EC) of the use of tax relief or other incentives

for the introduction of less polluting cars. This is also a victory for West German (and Dutch) policy over the British position. It also allows taxpayers as a whole to pay for up to 85% of the extra cost involved in purchasing a cleaner car or converting an older one to the new standards, at least until these standards have become mandatory. This use of 'economic incentive' changes the price structure and thus demand, ie relies on market forces whenever the PPP fails to persuade industry or the consumer to make the responses government policy requires (4). Economic incentives, or subsidies if you like, are therefore seen, in Germany, as an essential (if undesirable) ingredient of any environmental protection policy which the Government is determined to implement. It certainly acts as a 'carrot' to industry because it means that government assists in the creation of demand for new products.

Successful pollution control in industry means that both the environment and industry gain from the regulatory process. In retrospect, the German Government now believes that its tax relief scheme has done more to stimulate demand for cars than reduce emissions. This demand stimulation benefitted all vehicle manufacturers able to enter the German market. Creating a demand for greener products is therefore a major aspect of environmental policy, and one where one might perhaps argue, the Federal Republic has acted with more foresight than our Government here.

How much N0x is too much?

Central to the dispute about vehicle emissions has been the role of nitrogen oxides not only in acid rain damage, but as an urban health problem, and more recently, as contributors to 'greenhouse' chemistry. This last environmental issue came too late for the regulatory efforts made so far. British reluctance to do very much against 'acid rain' is well enough known and to some extent reflects objective environmental conditions at home. However, the general threat perception or risks related to this mixture of gases has increased in recent years and involves not only the direct impacts of acid deposition on fresh water and trees, but also synergistic relationships with ozone and peroxyacetyl nitrates (PAN).

The British estimate of nitrogen oxides emissions now stands at 2.3 million tonnes per annum, compared to 2.9 mt in FR Germany, where an ambitious catalytic clean-up programme for combustion plant is also underway and a commitment to a 30% reduction of 1987 Nox outut has been made, (the 30% reduction in SO2 reduction has already been achieved). The British NOx figure represents a significant upward revision from the 1.7 mt estimated in 1987. This change may relate to the recent commitment under the 1988 Sofia Protocol to the UNECE Convention on Long-Range Transboundary Air Pollution, which requires Britain to stabilise its NOx output at the 1987 level by 1994 (5). The leanburn engine would not have made compliance with this target any easier.

Industrial interests paramount

The vehicle emission debate was decided, for the time being and after years of skilful 'fiddling with the figures', by the admission of the inability of currently available high compression leanburn engines to reduce NOx emissions under reasonably realistic test driving cycles AND at competitive costs (6). The leanburn engine would not have been defended as fiercely by its manufacturers if it had not involved a major investment programme begun in the late 1970s, concentrated in the UK and promising a product of significant commercial advantage. This strategy was morally supported by a government keen to show progress, for its own reasons, in the realm of energy efficiency. Reversing this trajectory involved 'strategic revision costs' for both industry and government.

In January 1989 Dr. Longhurst of the Acid Rain Information Centre argued that 'it was illogical for the EEC to adopt standards ... significantly weaker than their industrial competitors' (7). Arguments of this type can only appeal to those companies, however, which are at the forefront of emission abatement R&D, have the financial capacity to translate this knowledge quickly into marketable products and also have their government's backing in the creation of the demand for this product. None of this applied in Britain during the mid-1980s.

The environmental challenge to industry is by no means over, it would seem. The US are about to increase further the stringency of their limits by another 60%, and many Germans consider the small car standards recently agreed as a 'swindle' and as already outdated (8). The standards adopted by the Stockholm Group, which includes Austria and Switzerland, are already more stringent than even the proposed EC ones.

In spite of this demise of leanburn as we know it, the negotiations I shall now describe, have produced a successful outcome for the European motor industry. It gained much time for adjustment and restructuring. All car firms have become profitable again and, I would argue, the tightening of regulations combined with economic incentives have assisted in this turn of fortunes.

Regulatory History and Recent Developments

What were these long drawn negotiations really about? Air quality hardly featured in them. They can be subdivided into four stages: prior to 1984, the Davignon Plan of 1984, the Luxembourg Compromise of 1985, the small car agreement and beyond.

Negotiations Prior to 1984

The Economic Commission for Europe (ECE), an United Nations body, agreed in 1970 on regulation ECE 15-00 which has

repeatedly been amended to ensure approximate uniformity of emission standards in Europe for trading purposes. Until 1983 emission regulation in the European Community simply followed the ECE regime, its aim being mutual recognition of similar national standards in the interest of trade. Harmonisation was assumed to come about by market forces and the definition of standards reflecting current best practice which governments could choose to enforce. While perceived as quite costly and onerous by industry (Whiston, 1981) (9), technical regulation during the 1970s was left to the relatively cosy bargaining between technical experts from industry and government. Air quality remained of relatively little concern in Europe and the growing stringency of standards in the USA was seen as an exaggerated response to particular meteorological conditions. Little attention was being paid to Japan.

Conflicts were resolved among industrial experts drawn from European vehicle manufacturers who are organised into the CCMC (Committee of Common Market Auto Constructors). This excludes the American owned companies. Decision-making was therefore industry centred, based on consensus and excluded environmental lobbies and institutions (10). The arrangements were most satisfactory to industry, because of the 'global' approach adopted. This meant that all regulations were considered together and trade-offs were readily negotiated. As European manufacturers had emphasised fuel efficiency over emission abatement in their R&D efforts, the fuel efficiency argument became the favoured justification for not supporting the adoption of more stringent emission standards. In any case, the whole regulatory system tended to adjust to what was already practicable as well as the lowest common denominator. Given the political realities in Europe, little else seemed possible.

The Germans, however, were not at all happy with this situation and began to make unsuccessful intergovernmental efforts to speed up these negotiations in favour of more stringent emissions control from the mid-1970s onward.

From research into the European car industry's response to gradually tightening environmental standards done at SPRU during the late 1970s, it can be concluded that the motor industry (especially the large European manufacturers of cars for the mass market) were pursuing two rather contradictory aims. They claimed to want nothing more than long-term regulatory uniformity, stability and certainty (the level playing field argument) and blamed politicians for not delivering this good. They also lobbied strongly for a distinct 'European' solution, with Ford in the vanguard. This meant a preference for emission standards and test cycle procedures technologically less demanding than those already applying in Japan and the USA. This European solution, industry argued in 1980, was already consuming about 10% of R&D expenditure (a great deal for certain companies plagued with serious financial

difficulties) and was also weakening their ability to devote themselves fully to fuel economy. This was still widely regarded as the environmental priority.

The position of the French motor industry was especially strong in these negotiations. The chairman of CCMC, a body which later advised the European Commission, was at that time also the chairman of Peugeot, possibly the last European producer to adopt catalytic technology. A senior French Transport Ministry official has chaired all the important technical committees for the ECE and EC since the early 1970s (11). In France, the environmental concern with acid raid and the technological capacity for catalytic conversion was probably even less than in the UK, at least until early this year when Renault decided to make a 'green image' the focus of its competitive strategy against Peugeot. As long as France held out against catalytic converters, the British effort to produce a cheap and clean leanburn engine seemed safe.

The peace of the ECE arrangements was rudely shattered in 1983 by West Germany in the shape of the German Minister for the Interior. Dr. Friedrich Zimmermann, a Bavarian lawyer from the Christian Social Union, had very recently gained office in Bonn and with it the responsibility for environmental protection, especially of clean air and from radiation. His electors included many small forest owners. At home, Herr Zimmermann had already promised that all new cars would require catalytic converters by 1986 as part of his Government's 'Save Our Forests' programme into which the Kohl Government had invested not only much money, but also its political reputation. Dr Zimmermann therefore demanded the almost immediate adoption of very stringent US type emission standards for the entire Community. For this he had very broad political support inside the FRG, with only the car companies, especially the producers of smaller cars (VW, Ford, Opel) seriously disturbed by this prospect. They needed more time and feared the impact of increased costs on exports. But would German drivers be able to obtain the unleaded petrol their clean cars would require? Bonn began to put strong pressure on Community institutions, and Britain's help with respect to the directive on the provision of unleaded petrol was much appreciated if perhaps misunderstood.

The 1984 Commission proposal (the Davignon plan)

The Community response to this German pressure was the 1984 draft directive from the Commission to which the House of Lords Committee responded in its 5th Report. This Committee realised that transition to stage two of this proposal would require threeway catalytic conversion. The 1984 proposal, while rejected, included one agreement which the Ministers did accept, namely that their goal would be emission standards which were 'US equivalent', a nicely ambiguous term which created and is likely to continue to create fascinating number games. This equivalence was to be

achieved in two stages by 1995.

The proposed numbers, on the other hand, proved quite unacceptable to some members of the car industry, and especially to those committed to the leanburn path. Ford and Fiat (a major producer of small cars) together, it appears, then suggested the compromise from which they both hoped to benefit, ie to relate emission standards not to cars by weight, but by engine size. This promised to make big German cars more expensive, medium cars with leanburn engines relatively cheaper and small cars, at the very least, would gain time to discover how they could best comply. In addition, and perhaps most importantly for national car companies, they would not become dependent on expensive Bosch patents for the lambda sensor and fuel injection systems. Medium sized engines would get away with being leanburn combined with simpler and cheaper oxidation catalysts to cope with HC emissions.

The Luxembourg Compromise of 1985

After a night of exhausting negotiations and, according to Herr Zimmerman, several phone calls to Mrs Thatcher in Milan, an agreement of sorts was finally reached in the summer of 1985. This included an increase in Nox values when compared to ECE Regulation 15-04, ie the combined value in gms per test of HC and NOx were to be 21 instead of 19 for cars with less than 1.4 litre engines. This would make life much easier for small 'fuel efficient' leanburn engines, for which the UK Department of Energy at that time claimed 20% fuel 'savings', a claim which infuriated the German experts.

The German Government was now in deep trouble at home. It had become clear that 'going it alone' was not politically practicable and was economically dangerous and that the European car industry had too much support among governnments to make rapid progress possible. Germany thus 'gave in' for reasons of economic interest and domestic legal pressure - its economic incentive scheme was to enter into force a few days later.

Luxembourg was widely seen as a defeat in Germany and may have contributed to Dr. Zimmermann later losing his responsibility for Environmental Protection to become Minister for Transport. He went back home even more determined to persuade the German motorist to buy cars with catalysts and to exploit the two remaining 'loop-holes': further negotiations on small cars and the test cycle. The dispute about the future of leanburn was by no means over, although cars with these engines were assured a market for a few more years.

Small cars, June 1989 and beyond

In 1988 it seemed that small engined cars would have to catch up with medium sized engines, but then Peugeot forced

the French Government to negate even this agreement. The European Parliament passed an angry resolution. A new driving cycle was, however, agreed at the expert (not political) level in early 1989, but will only apply to the new uniform standards yet to be agreed for all cars by 1990.

Clean small cars surely make environmental sense, because they make up about 60% of the European vehicle population and these values can now readily be achieved (12). Some can apparently achieve them even without regulated threeway catalysts. Catalytic technology has moved on and become cheaper, only the true leanburn engine is still not on the road. Would a bit more pressure in the mid-1980s have helped it along? The small car agreement of 1989 left medium-sized engines in an absurd position of requiring the least demanding technology.

British perceptions and motives

The development of leanburn engines was primarily a response to concern about CO and the energy crises of the 1970s. It also related to the genuine conviction that the trade-off between energy efficiency and emission abatement, which did afflict these new engine designs, could and should be decided in favour of the former. This conviction not only fitted in well with official rhetoric about energy efficiency, but combined with the genuine dislike of the mechanical engineering profession for sensitive, add-on devices which catalysts necessarily are. The dream of the truly clean as well as energy conserving engine is a powerful one and has had a persuasive political effect in Britain. At the very least, it provided a justification for all those who did not want, for whatever reason, a rapid transition to stringent emission standards.

Given the differences between Germany and Britain in the perception of environmental risks and damages arising from acid deposition, in industrial capacity as well as trade balances, serious conflicts of interest (some of which were never really made explicit in the negotiations in Brussels and elsewhere), were quite unavoidable.

It is more than likely that British industry, even without the promise of leanburn, would have needed a considerable time span to adjust to the changes demanded for competition in Europe. It is therefore very difficult to disentangle the two primary motives for what I believe to have been behind British resistance: the genuine debate about the 'best' technology for engine development in Europe and the tactic of gaining time. Should leanburn fail, a new leaner engine type could be marketed for long enough to recoup for British and other shareholders at least some of the investments made. For the British Government, I believe, the technology argument acted as a credible fig-leaf for motives it could not make explicit.

How the Germans did it

Car emission reduction was widely debated during the 1970s and in 1983 the German Government merely jumped onto a wagon which was already beginning to roll. The senior bureaucracy in the Interior Ministry in Bonn was deeply committed to a strategic approach to air pollution control (13). This meant that Government was less in need of 'science' to justify that there was or was not a problem, but rather needed technological solutions, the emphasis being on innovation and the creation of markets for new products. The preference for catalysts, given their impact on the elctronic component industry, could be explained by this emphasis alone; the perception of serious environmental damage only encouraged their social acceptability. Public opinion was therefore useful to government,and although I am not persuaded that it determined official policy, opinions here may well differ.

In 1971 the German Government adopted an environment programme with the goal of a 90% reduction of vehicle emissions over the next ten years (14). This objective was not achieved, but neither was it forgotten. Once the German lead debate was over, with the introduction of 0.15 grammes per litre lead petrol in 1976, the goal was reactivated in the sense that internal negotiations for its transformation into policy could begin. This, the Federal Government knew full well, would require the support of the public against the vehicle industry. In 1980, the Federal Environment Office published a pamphlet approved by the then Interior Minister which described the car as the nation's top environmental problem, and in which the Minister, Gerhart Baum, himself bemoans Germany's emotional and economic dependence on the car and declares that 'in future the quality of technology will only be assessed by its energy consumption and environment friendliness' (15). The pamphlet expressed the hope that both catalytic conversion and leanburn engines would provide the technological solutions for the problem. The car industry was not pleased. In 1987 a second edition using a more measured tone was published. However, any reference to leanburn as offering solutions had been abandoned.

In 1982 the Government fell and Herr Baum lost his job to be replaced by Herr Zimmerman who inherited a very full environmental agenda which the Kohl Government, after some hesitation, fully accepted and proceeded to implement with considerable energy (16). By 1983 the rise of the Green Party to national prominence, forest die-back and the continuing debate about nuclear power had created a situation in which air pollution arising from acid emissions became a major issue on the Conservative agenda (17). By first increasing uncertainty and thus reducing sales in the domestic vehicle market (1983 - 1985), and then convincingly threatening unilateral action in Europe as well as the imposition of speed limits, Herr Zimmerman succeeded in persuading the German car industry to take his goal, if not

his timetable, seriously. The car industry was and remains fiercely opposed to speed limits, but was prepared to make the necessary investments and adjustments for the adoption of catalytic technology provided Europe would follow suit eventually.

Not being permitted to introduce catalytic technology in a mandatory way, the Government had to adopt a voluntary policy and thus 'bribe' the consumer. The loss of tax revenue would be borne by the Lander. However, in Luxembourg Germany was allowed to temporarily offer tax rebates for cars already able to comply with the agreed European norms. The environmental lobby was furious, for the compromise meant that cars with engines below 2 litres, as well as all diesel cars, would also benefit. Industry was less unhappy, car sales rapidly picked up again, and although it appeared to have 'overinvested' in catalysts, the German Government now had two important new allies in its battle against leanburn, the German (and soon the Austrian, Swiss and Dutch) consumers, as well as those manufacturers which had made the required investments.

This fairly soon included Ford in Germany, where the company adopted a policy of maintaining market shares by offering 'polluting' cars at very favourable prices while making rapid adjustment to the new technology. It began its glossy advertising campaign for 'cat cars' in 1986 (18), something which did not escape the environmental lobby in Britain.

Nevertheless, surprise was expressed in both Germany and Britain when the June decisions on vehicle emissions were announced in Brussels. A more general look at the broader European context, especially at the French and Italian responses and Community institutions is also needed.

THE CHANGING EUROPEAN POLICY CONTEXT

Three sets of factors can be isolated as having brought about the eventual failure of leanburn technology.

Economic factors: profitability instead of fuel efficiency

The decision of June 1989 was acceptable to industry because its financial resources had improved considerably during recent boom years for which, I suspect, the German taxpayer was in part responsible. The energy efficiency argument widely deployed by the European car industry (and the UK government) looked increasingly less credible after 1984. Low fuel prices, in the absence of regulation, did not encourage the development of leanburn engines, in fact their advantages were rather used to improve performance. The real trade-off came to be not between energy efficiency and emission abatement, but between performance and emissions. Technological achievements by the Japanese also strengthened the view, expressed by OECD in 1988, that 'there need not be

any fuel economy penalties due to more advanced emission control systems' (19).

The overall fall in the cost of motoring, as well as consumer preference for larger, high performance cars which industry has encouraged and which most governments have done very little to correct, weakened the efficiency and cost arguments further. Most consumers clearly could afford more expensive cars equipped with a lot of electronics. The electronic components industry needed markets and the car offered itself as an excellent absorber of 'added value'. This in turn may have reduced the feared German competitive advantage which some companies had assumed would arise from stringent emission regulation. To make room for growth in consumption by producing cleaner products also became an argument increasingly attractive to industry and appears to have had a particularly strong appeal in Italy. Countries without car industries (Denmark, Greece) and very serious air pollution problems had the least problems in supporting the German position.

Political factors: the greening of Europe and the growing political cost of being considered 'dirty'.

The greater political salience of the 'environment' as being threatened by pollution (rather than resource shortages) has already changed the environmental policies of several countries. Environmental protection to the limits of affordable technology, long considered imperative in West Germany, thus became more attractive to politicians under pressure not only from voters but increasingly industry as well.

In early 1989 the German Government appeared reconciled to a 'two track' solution which divided Europe into a Northern and Southern zone on the basis of the 'test approved' composition of their car exhaust emissions. The politicians in the 'South' clearly did not like this solution. Italy set up an environmental ministry last year, and the ecologists did very well in the municipal elections in France in the spring of this year. Growing concern in Europe as a whole about air quality and global effects of air pollution and the ability of public concerns to influence the European political system, as demonstrated in the European elections in June 1989, both helped to bring about a change of attitude. The perception of environmental damage costs was clearly rising, with governments not always in the vanguard. I think that this change has been particularly significant in France.

New Institutions, the Single European Act and 1992

New institutions and decision-making procedures may also assist in bringing about policy change. The growing political will in the Commission itself, as shown by the new Italian Commissioner for Environmental Protection and the new German Commissioner for Internal trade. helped to push

the negotiations towards their present stage. As the political salience of 'the environment' increased, the environmental perspective in the Commission too began to assume greater importance. Not achieving its original aim of harmonisation at the lower level, unwilling to begin court proceedings against the Dutch for also adopting economic incentives, the Commission came to the conclusion that the European car industry was very well able to comply with higher standards.

Most importantly perhaps, the European Parliament itself had gained new teeth under the 1986 Single Act and had already made its opposition to the Luxembourg limits known. The Single Act now made it impossible for Britain to use its veto, for having rejected the decision of the Council, the Parliament now required that the Commission put a new proposal to the Council of Ministers which would be decided by majority voting. France was also eager to please the European Parliament because of signs that this body might want to move away from Strasbourg.

CONCLUSIONS

The underlying factor in the European opposition to catalytic technology came from a number of European vehicle manufacturers who needed time and money to adjust to new regulations. The weaker sections of industry found a strong ally in the British Government for reasons which relate to political, institutional and economic (eg trade balance) factors; in the German government, however, they faced an opponent with a strong enough industrial and political base to initiate change.

When industry claimed in 1984 that implementation of catalytic technology would cost Europe between £10 - £12 billion, only the German Government had a reply ready in terms of national environmental damage costs and political strategy (20). A lengthy process of negotiation and bargaining thus began in which commercial considerations and national protectionism created temporary compromises which primarily gained time for technological adjustments and restructuring in the industry, This is typical of international environmental issues with major industrial and commercial implications where time is of the essence.

However, environmental outcomes must remain in doubt because real retrenchment of consumption, eg of large and fast cars and growing individual mobility, are not being addressed. The environmental impact of catalytic conversion may well be decided by the inspection, maintenance and enforcement procedures still to be decided. The real battle about the ecological impact of transport is only beginning. Further regulation of diesel particulates and diesel fuel, of nitrogen oxide emissions from heavy vehicles, of evaporative fuel losses and noise from all vehicles, are already in the pipeline. People are again talking about the need for

'integrated' public transport. The challenge to the engineer will be great, that to the policy-maker and society even greater.

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Selected References

(1) New Scientist, 24 June 1989, p.77

(2) House of Lords Select Committee on the European Communities, Fifth Report 1984-85, HMSO, London 1985

(3) Proceedings of the Institution of Mechanical Engineers, Vehicle Emissions and their Impact on Air Quality in Europe, London 1987/88

(4) W. Benkert, 'Die Bedeutung des Gemeinlastprinzips in der Umweltpolitik', Zeitschrift fur Umweltpolitik, 3/1986, pp. 213-229

(5) Rt. Hon. N. Ridley, in Environment in Trust, DOE 1988

(6) E. J. Cutting, 'European automobile exhaust emissions - the fifth amendment', in (3) above, pp. 43-55; also H. R. Glatz, ibid.

(7) in Clean Air, Spring 1989, pp. 14-22

(8) Der Speigel, 17 April 1989, 22 April 1989 and 19 June 1989

(9) T. Whiston, Environmental Regulation and the European Automobile Industry, report to the OECD, SPRU, 1982

(10) G. R. Heaton & J. Maxwell, 'Patterns of Automotive Regulation: An International Comparison', in Zeitschrift fur Umweltpolitik, Berlin 1984

(11) Fritz Vorholz in Die Zeit, 30 December 1988

(12) The Environment Digest, no. 23 p.11, April 1988, reports the following experiment. A 1980 Golf GTI without any pollution abatement device driven over 1300 miles produced 50lbs of NOx; a 1989 Golf fitted with threeway catalytic converter, produced 8lbs.

(13) E. Muller, Innenwelt der Umweltpolitik: Sozial-liberale Umweltpolitik - (Ohn)macht durch Organisation?, Westdeutscher Verlag, Opladen, 1986

(14) This was first recommended by the Advisory Council for Environmental Questions in its 1970 report 'Auto und Umwelt'

(15) UBA, Dept for publicity & public enlightenment, was Sie schon immer uber Auto und Umwelt wissen wollten, Berlin 1980.

(16) H. Weidner, Die Umweltpolitik der konservativ-liberalen Regierung 1983-1988, WZB paper FS II 89-304, Berlin 1989

(17) S A Boehmer-Christiansen, Energy and Environment in the FRG: Forest versus Fossil Fuels?, SPRU Occasional paper No. 29, 1989

(18) H. Westheide, Die Einfuhrung bleifreien Benzins und schadstoffarmer PKws in der BR Deutschland mit Hilfe okonomischer Anreize, Erich Schmidt Verlag, Berlin 1987

(19) OECD, Transport and the Environment, Paris 1988, p. 105

RADON LEVELS AND EFFECTS

By

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Introduction

In recent years, radon has been recognised as the principal contributor to the radiation exposure of the population of the UK and other countries and as a source of very high exposure in some cases. As a consequence of this recognition, doses due to radon daughters in the workplace have become subject to control under the Ionising Radiation Regulations, and an Action Level designed to limit doses at home has been endorsed by the Government of the UK.

Radon in Homes

Surveys of radon in UK homes have been carried out since 1976, and by 1991, according to present indications should have covered about 24,000 homes. The NRPB systematic survey of 2300 houses throughout the UK (1) gave an overall average of 20 Bq/m3. This survey was carried out over a whole year in each home using passive detectors in bedrooms as well as living rooms, and so provides the best estimate of the exposure of the UK population. It is calculated (2) that 20 Bq/m3 in a house gives an annual effective dose equvalent of 1 mSv and a lifetime risk of 0.25% of contracting lung cancer.

The national survey reported above showed that the distribution of radon concentrations was log-normal, with a small proportion of homes having very high radon concentrations. These homes occur in areas of the country where a combination of the radium-226 content of the ground and its permeability to gas flow make large quantities of radon available at the surface. Details of house construction and the habits of the occupants affect the flow of radon-bearing soil gas into homes. Variability in these factors, combined with local variations in radium concentrations and ground permeabilities, results in large differences in radon concentrations within small areas. Surveys of radon in parts of Cornwall, Devon, Derbyshire and Scotland showed that some houses have radon concentrations of more than 1000 Bq/m3 (corresponding to an annual effective dose equivalent of 50 mSv), with one case being an order of magnitude higher.

In view of the high doses that can occur in houses, NRPB

advised the Government that an Action Level was required, above which householders should reduce the radon levels. The Action Level was set at 20 mSv/y1 or 400 Bq/m3, which was calculated to correspond to a lifetime risk of 2%. Later reviews of the risk data by ICRP and BEIR-IV led to a revised estimate of 5% at the Action Level (2). Although the original advice had made it clear that the Action Level would be kept under review, it was felt that the level should not be changed immediately to bring it into line with the changed risk estimates. This approach was affected by several considerations, not least the need to focus attention on the homes with the highest levels and to avoid a high level of demand for remedial measures before sufficient expertise had been built up to satisfy it. As the programme of surveying and remedying houses in South-west England becomes better established, however, it becomes more appropriate to reconsider the Action Level.

The Department of the Environment is sponsoring surveys by NRPB in various areas of England known to have high levels of radon in homes. Devon and Cornwall have the most severe problems, with an estimated 13,000 homes above the Action Level, so the most extensive surveys are being carried out there. These surveys have shown that there are some small communities where more than 30% of the population is exposed to more than 20 mSv per annum and about 5% are exposed to more than 50 mSv per annum. Surveys are also taking place in Derbyshire and Somerset under the DOE scheme, where the numbers of homes exceeding the Action Level are probably an order of magnitude less than in Devon and Cornwall. Similar surveys are being conducted in Scotland, Wales and Northern Ireland on behalf of the Departments of State.

The surveys discussed in this paper are likely to identify 1000 to 2000 homes above the Action Level out of an estimated number of 20,000 in the UK. Surveys targeted on the areas known to have the highest radon levels have a success rate of about 25% in identifying affected houses. As the surveys spread out from the highest areas, this success is likely to drop if the present procedures continue to be used to locate houses. It is therefore essential to develop better techniques to map areas of high radon potential, and this objective is being explored by NRPB with the British Geological Survey.

Measures Against Radon in Homes

Buildings are normally at a pressure a few pascals lower than atmospheric pressure owing to the effects of warm air rising and of wind blowing across openings. This underpressure draws soil gas containing radon into the building through cracks and gaps in floors and walls. Although radon concentrations in buildings can be reduced by increasing ventilation, in practice, significant reductions can be achieved only with ventilation rates that are uncomfortable and add substantially to heating costs. It is very difficult to seal all the cracks and gaps between a

building and the soil, so a more effective remedial measure is to create an underpressure beneath the floor to counter that in the building (3). This is done by creating a radon sump, a small hole under the floor filled with very porous material such as coarse gravel. The sump is connected by an underground pipe to a continuously running fan to draw radon from the sump and vent it to the outside air. This measure can reduce the ingress of radon over areas of tens of square metres, its effectiveness depending on the permeability of the ground under the house. Simple and inexpensive methods are also available to prevent high radon concentrations in new homes (4).

References

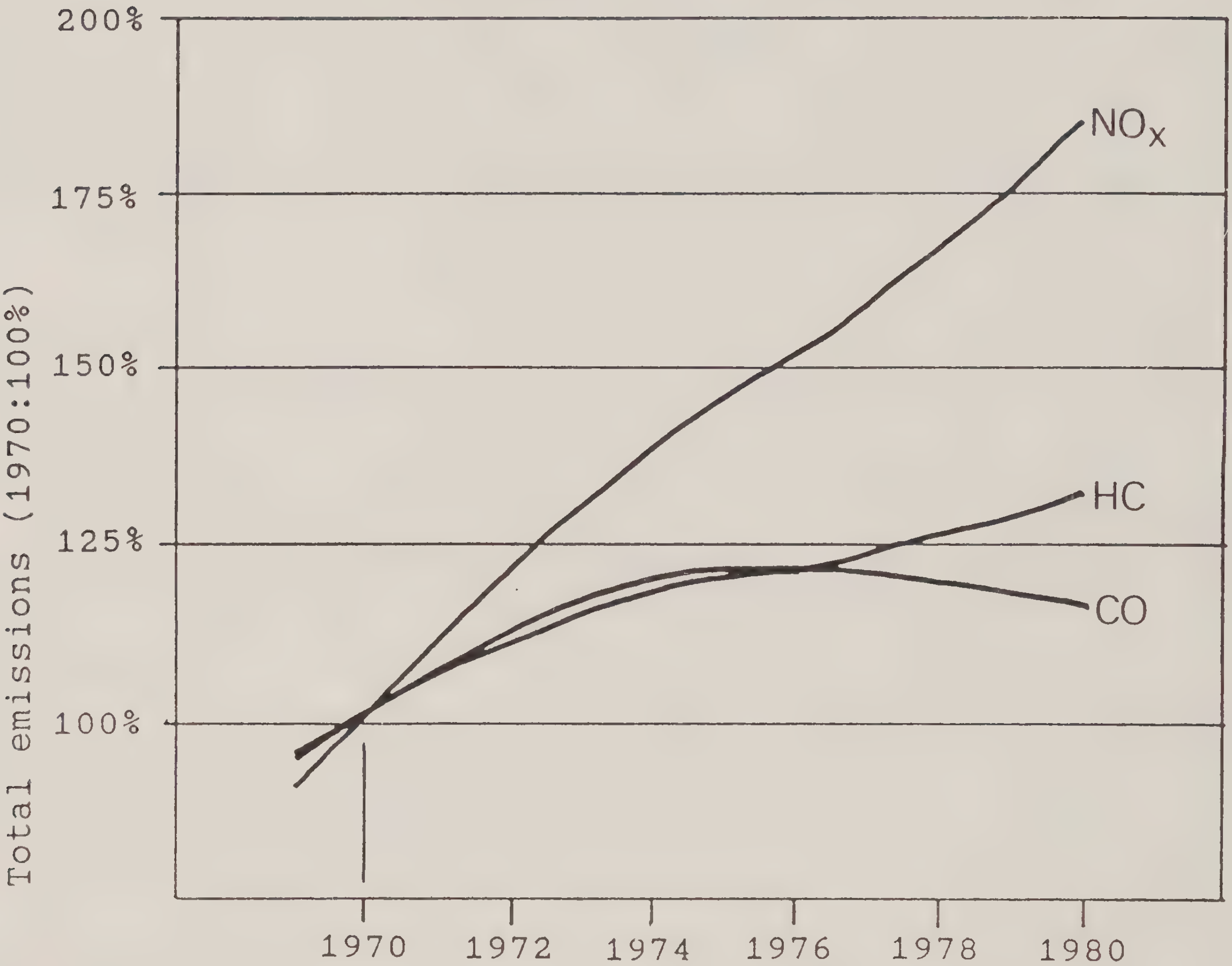
(1) Wrixon A. D., Green B. M. R. G, Lomas P. R., Miles J. C. H., Cliff K. D., Francis E. A., Driscoll C. M. H., James A. C. and O'Riordan M. C. Natural Radiation Exposure in UK Dwellings. NRPB Report R190. National Radiological Protection Board, 1988.

(2) O'Riordan M. C. Notes on Radon Risks in Homes. Radiological Protection Bulletin (1988), 89, 13-14.

(3) Department of the Environment. The Householder's Guide to Radon. HMSO, 1988.

(4) Department of the Environment. Building Regulations 1985 - Part C: Radon. Interim Guidance on Construction of New Dwellings. DOE, 1988.

Figure 1. Total emissions of pollutants from all vehicles with petrol engines.



Source: K Becker, (UBA) 1985

RADON - THE LOCAL AUTHORITY VIEW

By

Alan Blythe
Woodspring District Council

RADON - THE INVISIBLE, ODOURLESS HEALTH THREAT

"Radon is currently the worst public health threat in the environment". Not my words but those delivered last year by Dr. Julian Peto of the Institute of Cancer Research at the Radiology '88 Conference of the British Institute of Radiology held in Glasgow. Amongst Dr. Peto's other more quotable remarks was that "the radon risk to health is over 1,000 times worse than asbestos". Dr. Sarah Darby of the Imperial Cancer Research Fund Epidemiology Unit speaking at the same conference, cited the BEIR (Biological Effects of ionising Radiation Committee) estimate that the UK average exposure to radon of 20 Bq/m3 equates to a 0.25% life risk or, in real terms, 1500 to 2,500 extra deaths per year!

So, what of the risk associated with over 400 Bq/m3 - the present action level - accepted by the Department of the Environment at 20 times that figure? And what about the real risk to health for the thousands of UK citizens exposed to in excess of 1,000 Bq/m3 per year (equivalent to a dose of 50 mSv/y per year)? The current ICRP (International Commission on Radiological Protection) recommended principle limit for average life-time radiation exposure is one mSv/y (1) over and above this much larger natural radiation contribution. If we couple innocent high radon exposure with smoking - still sadly afflicting around 30% of our population - then the health risk does not merely summate - it multiples.

Last year the IEHO conducted a national radon survey - not in any attempt to supplant, denigrate or contradict the earlier NRPB 2,309 house survey or later 17,000 house survey, but to add local, independent information to the still arguably obscure UK radon picture - a picture which is hopefully that much clearer now because of IEHO and Local Authority collaborative efforts. We have mounted a second national survey this year too, whose results are still being interpreted for publication and which covers 1300+ homes.

The IEHO became interested in radon following the Tenth Royal Commission Report on Environmental Pollution (Tackling Pollution - Experience and Prospects). This detailed the nature of the radon health hazard. It noted that random produces radioactive decay; some of the radioactive particles in the air are inhaled and retained in the lungs which can in turn lead to lung cancer - a hazard which is aggravated by smoking. The RCEP also reiterated the ICRP

recommendations for limiting public exposure to radon.

The Tenth Report re-stated NRPB risk estimates from their 1986 Survey of 2000 homes as a national annual average dose equivalent to 800 mSv. If this estimate is then applied to lifetime exposure at various indoor levels the following is obtained for the UK:

Annual effective dose equivalent: less than 5 mSv.

Estimated that:

- in c.1000 homes annual effective dose: more than 5 mSv but less than 25 mSv.
- in c.1000 homes annual effective dose: more than 25 mSv

For the average person the lifetime risk from radon exposure is one per cent the risk of lung cancer from all causes and 0.3% of the risk of all cancers from all causes. It is, however, difficult to identify homes with excessive radon doses as insufficient is known about the variation between houses to make predictions.

The Royal Commission comments citing the difficulties of identifying highs and local variations, I think, will stand the test of time and suggest - together with our own survey results - that much more exploratory survey work needs to be done. So how did IEHO tackle environmental radiation generally? Well in true British fashion we formed a radiation monitoring working party which I chaired which included radon in its remit.

We looked at the basic fact that radon was thought to constitute in 1987 (2) on average 37% of UK public radiation exposure and we checked the medical evidence. The Final Report of the Working Party, Environmental Radiation Monitoring, was published in 1988 and the final chapter was devoted to radon. This restates the basic science of radon and reviews those NRPB estimates of houses affected. (see box).

<u>Science of radon</u>

It diffuses to the surface via pores and cracks

Its daughters, eg Polonium 218
Lead 214
Polonium 214

gathers inside dwellings;
potential danger to health;
Alpha-particles emitting radioactive aerosol

<u>NRPB Estimates</u>

The NRPB estimates c. 20,000 dwellings suffer indoor radon

dose rates of more than 20 mSv pa, (400 Bq/m3 - the so-called action level). Other estimates are:

2,000 dwellings exceed 50 mSv/y (1000 Bq/m3)
50,000 dwellings exceed 10 mSv/y (200 Bq/m3)

In November 1987 we launched our 6 months' radon survey - originally planned to cover around 135 Local Authorities, but later revised to 121 from whom we have had results so far. The participating Local Authorities were widely spread on a random geographical, geological and political basis, specifically not recognising traditionally known "hot" or "cold" radon areas. So what did the average Environmental Health Department do? In my own District we looked at the local geology, and produced maps showing geological deposits in our area. In the southern Woodspring/Weston-super-Mare area there are deposits of carboniferous limestone, alluvium, lias and marls and blown sand, which contrast in the north of Woodspring with sandstones, peat, marls and shales. We transferred the data gathered to a computer spread sheet and plotted grid references, individual house structural details, age, floor types and usage over the period of detector exposure because we knew that radon enters the home in a variety of ways such as via cracks in floors and walls, and through gaps around pipes, cables and drains; it can percolate up through cavities and through construction joints; we know too that it prevented from dissipating or is even exacerbated by, for instance, blocked air grates, double glazing, or otherwise sealed windows, restricted fireplaces, or the open fire "suction/ventilation" effect.

As the Final Report indicates, we used "Tastrak" detectors which, I understand, are a polymer of diethylene glycol bis (allyl carbonate) manufactured by Track Analysis Systems Ltd. of Bristol University to rigorous "clean room standards". These, for convenience, were housed in small plastic pots which were distributed amongst mainly staff, and homes of councillors to allay any possibility of public resistance or anxiety and hopefully left in a safe position. These were collected after 6 months' exposure and taken back to the laboratory where the detectors which had previously been pre-scribed with the now ubiquitous bar code for automatic computer identification, were unpacked and the sensitive plastic mounted on the microscope stage. A scanning television camera picks up the individual alpha particle tracks after chemical etching under controlled conditions. A fully automated image analysis system locates, measures and recognises tracks based upon a "Microvax" computer with fully automated scanning to a pre-programmed sequence. The computer recognises the dosemeter code, scans it and records the dose individually; subsequent data analysis automatically calibrates each dosemeter and corrects it for fading. Seventy dosemeters can be scanned within 6 hours.

Results

Incorporating, as you will recollect, 121 Local Authorities, radomly spread right across the UK giving a total sample of 2,583 homes where detectors were successfully recovered. Before I detail our results, I really must emphasise the importance that the IEHO has given to confidentiality in the matter of radon reporting and hopefully something that many of you will have picked up from some of the radio broadcasts that have since taken place on this subject. You will notice that I will only refer to regional or county trends in this our snap-shot 6 months' survey. I will specifically not divulge the identity of individual participating Local Authorities because we emphasise that Local Authority results are their own property and they must release or withhold them at their own discretion. Similarly, we have advised Local Authority CEHO's that the law of tort - put simply the possibility of householders' suing Local Authorities or their individual officers for compensation if potentially damaging information is released which could affect property values and could reasonably have been foreseen to have had that effect. This dictates that access to individual results is restricted to one, or at most, two named Local Authority officers, who the IEHO recommend should confidentially notify householders of their preliminary estimated radon exposure, and offer definitive twelve month follow-up tests either free, through the resources of the NRPB, or if needs be, at the Local Authority's expense.

But, of course, we are offering a truly independent, locally based objective public protection service - our advice to participating Local Authorities with "moderate" above "investigation level" of 1/2 "action level", "above action level" or "high" readings is that they should plan further District surveys from these initial "seed hot spots" - again in collaboration with the NRPB using their standard postcode method or, as I said, independently on the basis of individual resource availability, bearing in mind our "rock bottom bargain basement price" for "Tastrak" detectors.

So, indicated only by region or country for the reasons previously given, a total of 86 samples showed concentrations of between 100 and 200 Bq/m3, whilst 32 samples (or 1.24%) showed concentrations between 200 and 400 Bq/m3. At this significant bench mark of over 200 Bq - the current "investigation level".

- At the IEHO Target Action Level (Table 1) - a total of 43 readings were obtained. Extrapolating this 1.66% crude figure over the estimated 21 million national housing stock and applying correction factors for occupancy, floor level and seasonal variation, we arrive at an estimate of just over 250,000 UK homes affected (4.5 times the "official" estimate!).

Table 2 represents 9 readings from Avon, Dorset, Lancashire,

Northamptonshire, the West Midlands, Clwydd and Mid Glamorgan, of between 400 and 1,000 Bq/m3. Similarly our corrected estimate is 59,000 homes nationally over the current action level, when the NRPB estimate only 20,000 (a factor of 3).

Table 1: <u>IEHO TARGET: more than 200 Bq m^{-3}</u>

GS 6 findings = 50,000 dwellings
IEHO findings = 1.66%, more than 200 Bq m^{-3}
(350,000 dwellings)

(corrected 230,731)

Table 2: <u>more than 400 Bq m^{-3}</u>

GS 6 findings (2309 samples)
= 0.2% houses more than 400 Bq m^{-3}
(20,000 dwellings)

IEHO findings = 0.43%, more than 400 Bq m^{-3}
(89,000 dwellings)

(Correction applied for usage and occupancy
= 59,000 dwellings)

Table 3: <u>more than 1000 Bq m^{-3}</u>

GS 6 findings = 2,000 dwellings

IEHO findings = 0.077% more than 1000 Bq m^{-3}
(16,260 dwellings)

(Corrected 10,732)

Table 3 represents our two results over 1000 Bq/m3 which came from Cumbria and Staffordshire and represent around 10,732 dwellings nationally as compared to the NRPB estimate of 2,000 - yet another factor difference of around 5 times. You may also like to reflect that our sample survey did NOT include homes within the "known" highest radon area of SW England and the North East of Scotland but, conversely, our detectors were exposed in living areas only and over a winter period, which could tend to skew our estimates

upwards over a year long exposure period covering whole house occupancy by something like 50%.

So, after applying the various correction factors to our results, our conservative estimate of approximately 2 to 3 times the currently perceived problem - that is at least 40,000 to 60,000 homes whose inhabitants are exposed to radon at over the current action level - (400 Bq/m3 or 20 mSv/yr) seems reasonable.

These results have all been compiled into a report Radon: Report of the IEHO Survey on Radon in Homes 1987/88, which is available from IEHO Headquarters and draws together the following trends in radon concentration by house age, (Table 4), wall construction (Table 5), floor level (Table 6), floor construction (Table 7), and windows, (Table 9). Of course, the type of windows and glazing had a bearing - secondary glazing incorporating draught stripping and thereby further limiting air change, a significant "high".

It is IEHO official policy not to accept 400 Bq/m3/20mSv/y1 as a viable public protection action level. It is worth mentioning that we had no prior knowledge of last years's American announcement to reduce their own action level to 150 Bq/m3 - it really was pure coincidence, but it does show why our claim for a reduction of the UK official action level to 200 Bq or 10 mSv/y is even more sustainable and perhaps I should explain why.

The NRPB GS6 publication (3) entitled "Exposure to Radon Daughters in Dwellings" of January 1987 tabulated the lifetime risk of premature death from radon at the current action level (Table 10), (remember 400 Bq/m3, 20 mSv/y), at 2% - and equally note our present IEHO target action level of 10 mSv/y at 1%). However, following the downward revision of risk estimates in response to the ICRP Como Statement of 1987 (4), the NRPB reviewed its own risk assessment of the action level to 5% (in Radiological Protection Bulletin (5) number 89 of February 1988), but came up with a similar estimate of lifetime risk that 2,500 persons may die of lung cancer each year from indoor exposure to radon. Our call for a DOWNWARD revision to HALF the current action level would restore the risk factor back to around 2.5% - still arguably higher than that promoted as acceptable in 1987 but infinitely more defensible than the current 400 Bq/20 mSv/y action level. The NRPB still defend the safety of this ACTION level, despite reassessing average public exposure to ionising radiation to be highest of all from natural sources (87%) and some 14% higher at 51% from radon and thoron (6) than its 1987 estimates suggested (contrast these figures with exposures from nuclear discharges which constitute less than 0.1% of the overall total.

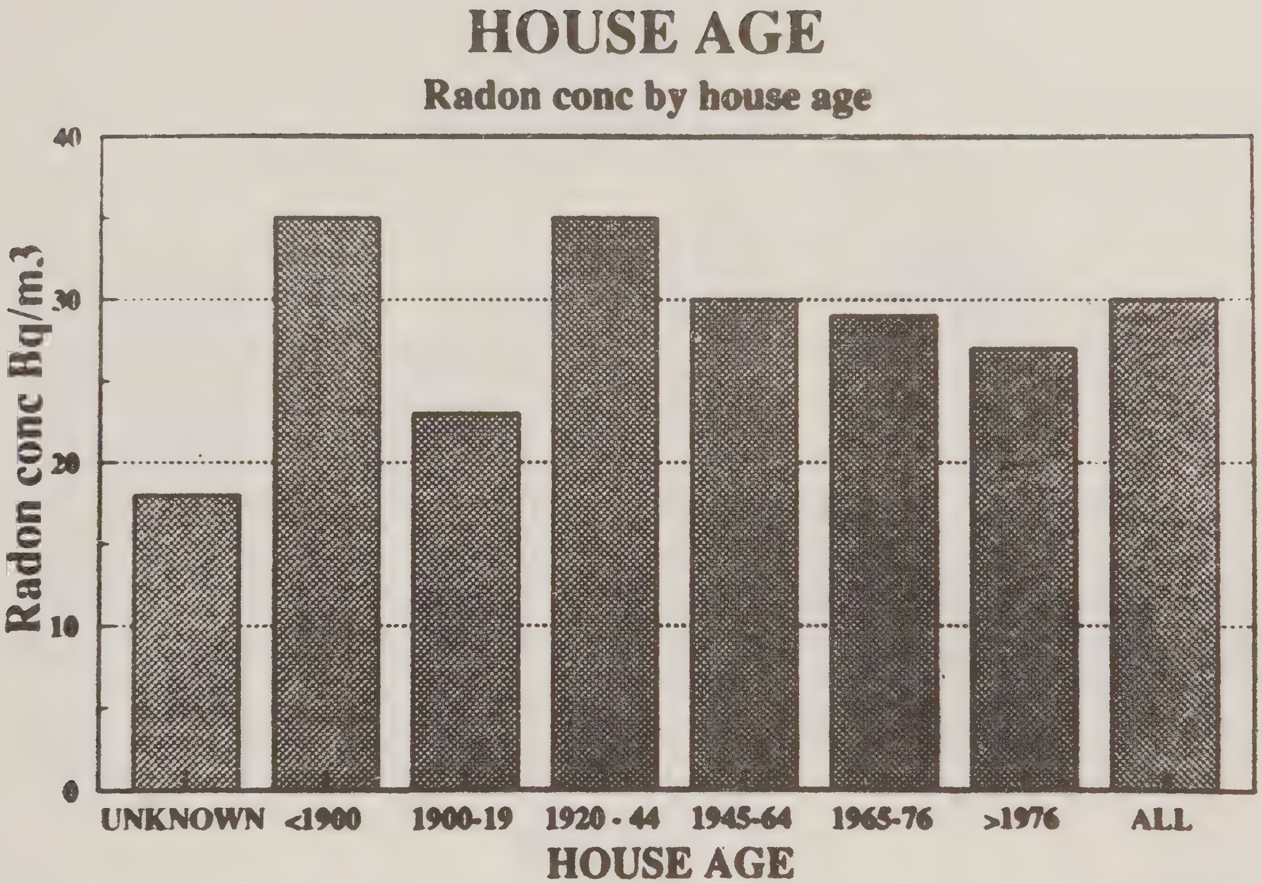


Table 4

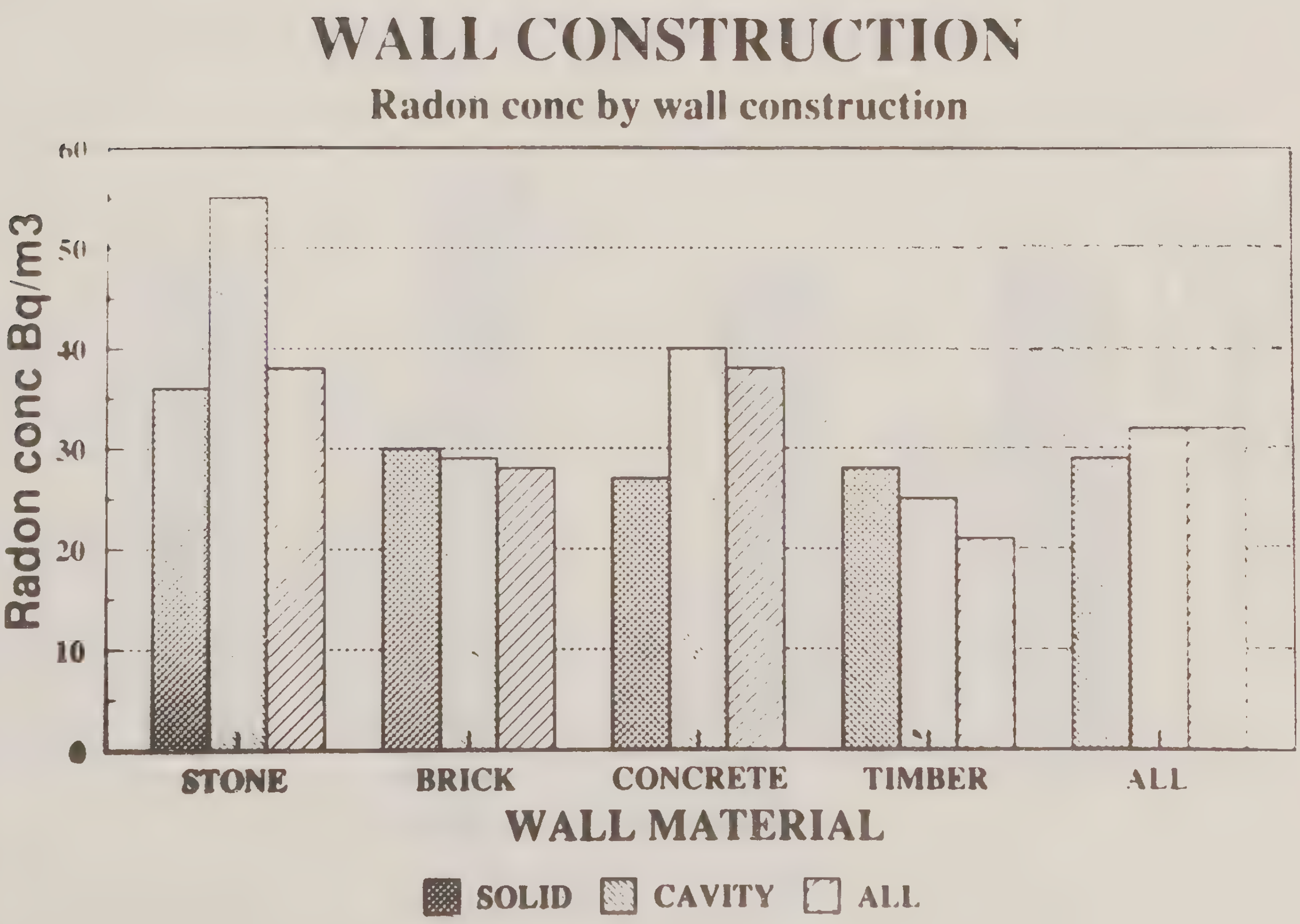


Table 5

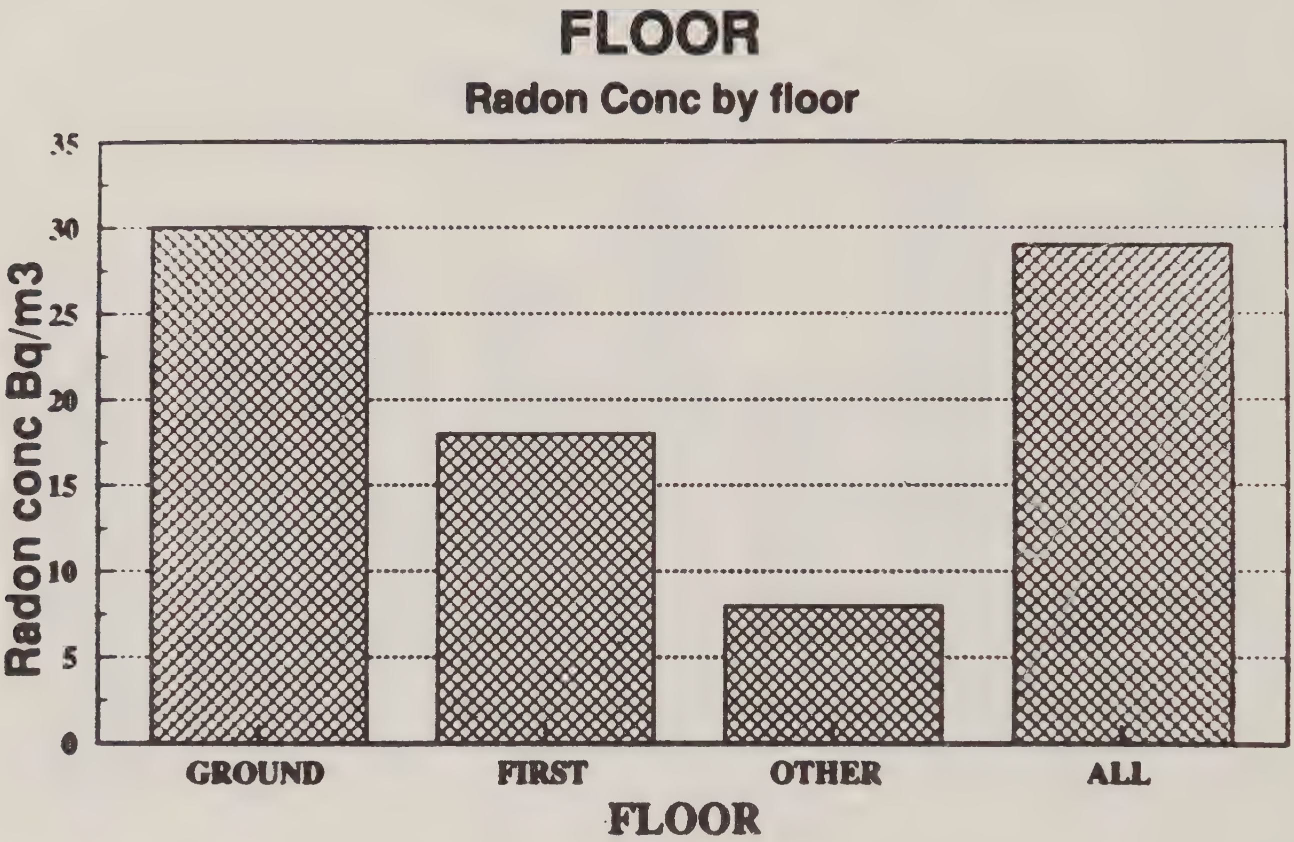
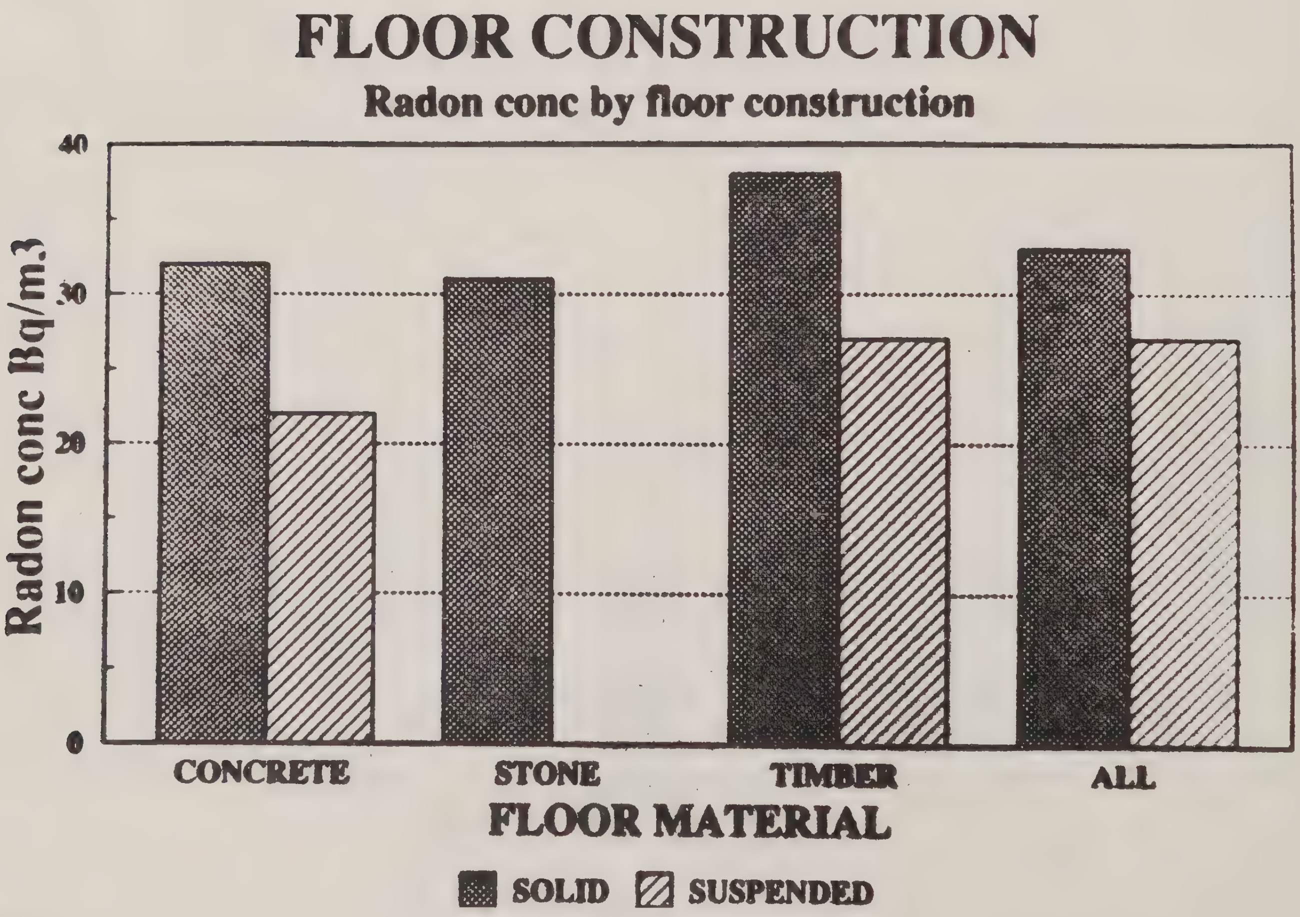


Table 6



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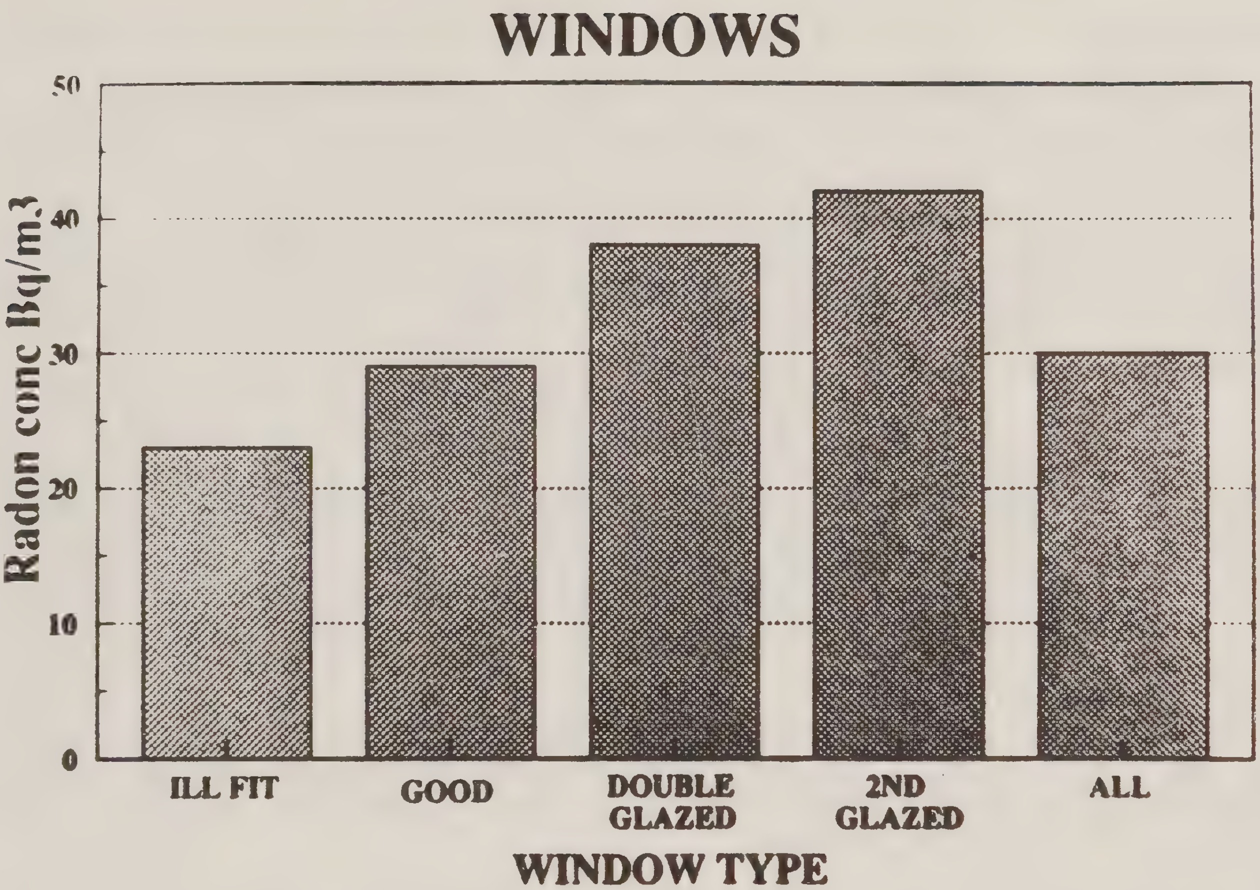

Table 9

Table 10 NRPB GS6 (JANUARY 1987)

CAUSE	RISK %
Malignant neoplasms (all causes)	25
Radon daughters, 100 mSv y^{-1}	10
Malignant neoplasms, bronchus and lungs (all causes)	6
Radon daughters, 20 mSv y^{-1}	2
Motor Vehicle traffic accidents	1
Radon daughters, 10 mSv y^{-1}	1

Conclusion

1. The IEHO National Radon Survey has proved that there are substantially more people exposed to elevated radon levels in their homes than had previously been predicted.

2. The direct risk to health is proven and the methods advocated by the NRPB, and DOE, through the Building Research Establishment are well rehearsed and are relatively cheap (estimated at an average between £500 & £1,000 per house).

3. Whilst the IEHO applauds that priority be given towards helping traditionally high radon areas, such as the south west of England, where NRPB are working very well with our colleague EHOs, our surveys do indicate hitherto upredicted radon "hotspots", which should stimulate urgent and more detailed additional national radon surveys in which Local Authority EHOs could collaborate in a cost-effective manner.

IEHO Recommendations

1. The ACTION LEVEL for existing homes to be reduced by 50% to 10 mSv/y (200 Bq/m3 and the INVESTIGATION LEVEL to be 5 mSv/y (100 Bq/m3).

2. The radon concentration justifying remedial action within ONE year what we would term the PRIORITY ACTION LEVEL - should be reduced from 50 mSv/y to 40 mSv/y (800 Bq/m3).

3. Extend the mandatory House Renovation Grant provisions to include all dwellings with radon levels above the prevailing action level, irrespective of age or ability to meet the other qualifying conditions of grant aid for housing.

4. National radon surveys to be expanded to include all areas of the UK within a rolling programme of regional appraisal, with Local Authority EHOs collaborating cost effectively with NRPB.

5. New legislative powers to be introduced:-

   (a) To enable Local Authority EHOs to serve statutory notice on landlords to remedy tenanted dwellings found to be above the prevailing action level (suggests the amendment of Radioactive Substances Act 1960).

   (b) To introduce a new system of Radon Certification of houses at the time of sale or resale so that new owners have a statutory right to information in respect of radon testing and remedy.

6. Further epidemiological studies to be mounted to quantify the synergistic link between smoking and radon concentration.

References

1. International Commission on Radiological Protection (ICRP) "Principles for limiting exposure of the public from natural sources of radiation" Pergamon Press ICRP Publication 39 AM ICRP, 14, No. 1 (1984).

2. National Radiological Protection Board (NRPB) "Living with Radiation. HMSO ISBN 0-85951-255-X (1986).

3. NRPB - GS6 "Exposure to Radon Daughters in Dwellings" ISBN 0-85951-281-9 HMSO (Jan 1987).

4. NRPB - GS9 "Interim Guidance on the Implications of Recent Revisions of Risk Estimates and the ICRP Como Statement". ISBN 0-85951-293-2 HMSO (Nov 1987).

5. NRPB "Radiological Protection Bulletin No. 89". ISSN 0308-4272 (Feb 1988).

6. NRPB - R227 "Radiation Exposure of the UK Population - 1988 Review". ISBN 0-85951-312-2

PASSIVE SMOKING - CONTROL OPTIONS

By

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INTRODUCTION

In March 1988 the fourth report of the Independent Scientific Committee on Smoking and Health (the Froggatt Committee) said that passive smoking - breathing other people's tobacco smoke - can increase the risk of lung cancer in nonsmokers and might lead to:

> ... several hundred out of the current annual total of about 40,000 lung cancer deaths in the United Kingdom ...

Apart from that risk, passive smoking can also affect: asthmatics, bronchitics, young children and pregnant women; as well as causing sore throats, cough, allergic reactions, irritating the eyes and nose, and making the hair, skin and clothes smell. This means that passive smoking in the workplace and public places such as cinemas, buses and restaurants, can represent the largest single health hazard and irritant in indoor air.

To eliminate this hazard the Froggatt Committee said that:

> ... non-smoking should be regarded as the norm in enclosed areas frequented by the public or employees, special provision being made for smokers, rather than vice-versa.

In fact, the Froggatt Committee report came after other important bodies, such as the World Health Organisation and the United States Surgeon General, had also reviewed the scientific evidence and agreed that nonsmokers can get lung cancer from passive smoking. It is not surprising, therefore, that repeated opinion polls have found that the overwhelming majority of the public wish to see restrictions on smoking in the workplace and in all public places. Eighteen months after the Froggatt Committee report, it is pleasing to note that most people have stopped arguing about whether nonsmokers should be protected from passive smoking. Instead, they are discussing, and seeking advice about, where smoking should be restricted and how.

Prospects for smoking control

In almost every area the problem of how to reconcile the nonsmoker's "right" to smoke-free air with the smoker's "need" to smoke can be solved amicably and permanently.

These areas can be divided into two categories:

1. Those where the risk is greatest, because an individual spends long periods of time there. This is mainly the workplace.

2. Those where people either have to enter, but spend relatively short periods in, for example, public transport or local government services; and/or those areas which people enter to take advantage of, or enjoy, a service as a paying customer, such as restaurants.

The greatest pace of change to nonsmoking as the norm is taking place in the workplace.

1. THE WORKPLACE

In the United States about 65 per cent of companies have a formal smoking policy. The majority of those policies make nonsmoking the norm and provide a smoking room where smokers can go and smoke without affecting their nonsmoking colleagues around them. In the United Kingdom the day is not very far off when we too will have a majority of workplaces that have a smoking policy. Already, a 1988 survey, by NOP for the Office of Population Census and Surveys, has shown that 49 per cent of workers report some form of restrictions on smoking. A few years ago only a handful of workers would have been able to report this, although an NOP poll in 1987 found that 81 per cent of smokers agreed that nonsmokers should have the right to work in air free of tobacco smoke.

It is now clear that many employers are responding to pressure from the workforce for a solution to the smoking problem, and are aware of their duty, under the Health and Safety at Work etc. Act 1974 to protect employees from "risks to health" and to make "arrangements for their welfare at work". They accept that, as passive smoking is now a proven risk to health and clearly affects the welfare of many employees, the day will come when a court establishes that the Health and Safety at Work Act includes passive smoking under its terms. They are acting in advance of any possible legal action. That they are able to do so is because clear rules and procedures now exist to help employers introduce a smoking policy to their workplace.

These rules can be summarised into five easy steps:

1. **Form a working party to work towards a policy.**

   This working party has overall responsibility for the process. It should consist of representatives from all areas of the workforce, including smokers and nonsmokers, and have a mandate to introduce the smoking policy from the highest possible level - e.g. the Board.

2. **Inform the workforce what is being done and why.**

A policy has to be introduced into a receptive atmosphere and the first task of the working party is to tell the workforce what they are doing; why - i.e. because of the risks from passive smoking etc; and how they plan to go about doing this. The information campaign can be conducted using existing methods, such as in-house newsletters etc.

3. **Consult with the workforce.**

As the smoking policy is potentially a change in the contract of employment, and almost certainly a change in the terms and conditions of employment, employers have a legal obligation to consult with the workforce. This is done using an attitude survey, to find out information which the working party will use as a guide when drafting the policy. It should be noted that there is no obligation to <u>ballot</u> the workforce. If the survey shows a majority for or against the policy, the working party should still draft the policy, taking into consideration other factors, such as number of smokers, building layout etc.

4. **Drafting the policy.**

Once all information has been gathered, the policy can be drafted. It should be kept simple, no more than one or two sides of A4 paper. It should be clear about where and when smoking is and is not permitted, and should make it clear that any breaches of the policy will fall under normal disciplinary procedures. The best, and most common, policy is one that makes nonsmoking the norm, but provides a designated smoking room(s) or area(s). The draft policy should then be circulated for discussion and comment and any suggestions for improvement taken into account.

5. **Implementing the policy.**

Once the policy has been agreed it can be announced that it is going into force. For legal reasons, there should be twelve weeks between announcement and implementation of the policy. Use this period to prepare the workplace and the workforce for change: order "no-smoking" and "smoking permitted" signs; prepare the smoking room(s) if these are to be provided; provide every member of the workforce with a copy of the policy and write it into the terms and conditions of employment. Most importantly - provide help and advice for smokers to help them to adjust to the new working conditions. Many smokers will want to use the policy as an opportunity to give up, help them to do this by providing leaflets, in-house stop smoking groups, and even one-to-one counselling sessions with a stop smoking expert. Others will only want to adjust their smoking pattern to cope

with the new restrictions, and managers should be instructed to be flexible to help smokers to do this, providing it does not undermine the policy.

Today many companies have followed these Five Steps to A Policy: BP, IBM, British Gas (Wales), Birmingham City Council, Ashford Borough Council and the Cabinet Office are just some examples of organisations that have implemented policies in the past few years. Their example is encouraging others to follow, and it is likely that most major organisations have the development of a smoking policy somewhere on their agenda.

It is interesting to note that the private sector is now leading the way in introducing smoking policies. Although many local authorities have policies, government departments have been slow to respond to pressure from their workforce and seem to get "bogged down" in the policy process. In fact, at the time of writing, even the Department of Health, which funds ASH, has still to announce its own smoking policy! This is a pity, when it is realised that not only is a policy popular with nonsmokers, but smokers welcome the policy as a means of helping them to give up, and as a welcome solution to the constant disputes with nonsmokers about smoking in the office.

2. PUBLIC PLACES

In other areas, policies to control smoking are being introduced more and more. Overwhelmingly, these policies are being introduced in response to customer demand and many businesses now find that smoke-free air is good for business.

Perhaps the best known area of change is one that people once thought would never happen. There was a very powerful image of cinema goers viewing Humphrey Bogart smoke his cigarettes through a smoky haze in the auditorium! Today, there is probably not one major cinema chain that still allows smoking in their auditoria, and many other cinemas are following suit. Yet there has been no outcry, no revolution by smokers. It is agreed that the only sensible way to protect nonsmokers in cinemas is to have a complete no-smoking rule. In fact, attendance at cinemas is increasing and, I'm sure, the rebirth of cinema-going has been helped by the introduction of smoke-free air. No-smoking rules introduced into other areas are having similar results.

An NOP poll in 1987 found that 66 per cent of the public thought that there should be no smoking in public transport. Transport operators are now responding.

Bus companies are leading the way. They have accepted that it is impossible to adequately separate smoking and no-smoking sections on buses and, therefore, the rule is now "No smoking at all". In almost every case the bus company

has reported overwhelming public support and that the no-smoking rule is good for business. Two comments will illustrate this:

> "I feel I must write to congratulate you on making the decision ... I for one will choose you and enjoy the ride and the atmosphere."
> (Passenger to the bus company)

> "It is in the interests of everyone ... and I believe it will save money on cleaning the vehicles, which will make it easier for operators to provide a good service to the travelling public."
> (Passenger transport watchdog)

At the time of writing, ASH hears every week of at least one more bus company that has introduced a no-smoking rule.

On planes, encouraged by the experience of Air UK and Paramount Airlines, British Airways conducted their own passenger surveys about smoking. As a result, in late 1988, BA introduced a no-smoking rule in response to customer demand on all their domestic flights. It is only a matter of time before this is extended to cover longer journeys and one day we may even see no-smoking flights to and from the USA.

Even British Rail has, on some Inter-City routes, complete no-smoking coaches. However, they still insist on leaving, on some routes, the half smoking, half no-smoking coaches with no physical divide in between, despite the fact that this obviously does not work. ASH would like to see the reintroduction of the "smoking carriage" by BR, as the only place where smoking is permitted, leaving the buffet, toilets and corridors smoke-free.

Apart from transport, where the size and architecture means that smoking and no-smoking areas are hard to provide, and the rule has often been no-smoking at all, there are other places which provide smoke-free air and also continue to allow smoking.

Contrary to popular belief, there are already in existence many pubs which provide a smoke-free bar. In fact surveys have repeatedly shown that the demand for smoke-free air in pubs is there, just waiting to be tapped. The NOP poll of 1987 found that half of nonsmokers would be more likely to visit a pub if it did not allow smoking. In 1988, a Which? magazine report found that people, when asked which change they would most like to see in pubs, put no-smoking rooms top of their list, above longer and more flexible opening hours! However, only a few breweries have dealt with this consumer demand seriously, two examples being Youngs in London and Brains in Cardiff. It seems that the pub-goer must speak up more strongly for smoke-free air before they will get what they want - perhaps the Campaign for Real Ale might like to be a Campaign for Smoke-Free Air as well.

But, proprietors have been slow to respond in an area where there is the greatest demand for change. The 1987 NOP poll found that nine out of ten people thought that all restaurants should provide no-smoking areas. Many people, including smokers, simply do not wish to pay for a meal only to have it ruined by being forced to breathe other people's tobacco smoke. In June of this year ASH launched its Bon Appetit campaign to change this. This campaign centres around a brochure, aimed at the proprietors of restaurants, which explains why they should have smoke-free areas, mainly because it will be good for business, and how to introduce these areas. The brochure even includes a new range of specially designed signs which they can use to make the change to smoke-free air.

ASH expects that the brochure will primarily be of use to Environmental Health and Health Education Officers, who are being invited to buy bulk supplies for use within their own area. Using Bon Appetit the EHO or HEO can visit a restaurateur and ask them to think about smoking areas, essentially saying - "Provide a choice for the customer and you will see the difference."

In fact, along with Health Education Officers, it is the local authority Environmental Health Officer that acts as the "front line soldier" in the campaign for smoke-free air in public. Both of these health professionals have access to employers and public service proprietors as part of their normal duties, and this allows them to point out the hazards of passive smoking and the demand for change.

Local authorities are also responding to public demand and introducing smoking policies into areas directly under their control. They are making the public areas of their town halls smoke-free, as well as recreation centres, community centres, and so on. They are also introducing smoking policies that apply to staff offices and council chambers. In both of these the local government union NALGO has been of prime importance in initiating and supporting moves to smoke-free air.

SUMMARY

In short, there is a real trend towards smoke-free air in the workplace and in public places. This trend is being fuelled by two factors:

1. The clear scientific evidence that passive smoking can cause lung cancer in nonsmokers.

2. The overwhelming demand for smoke-free air by workers and consumers.

Today, we can respond to that trend by showing that smoking policies are achievable and long lasting. There is now

every reason why nonsmokers should expect, and get protection from passive smoking. We can see the time when nonsmoking will be the norm in society as a matter of public health and consumer demand.

DISTURBANCE CAUSED BY NEIGHBOURHOOD NOISE

By

Dr. Bill Utley
Building Research Establishment

Summary

A survey of a representative sample of the adult population shows the problem of neighbourhood noise disturbance to be a complex one. People may be bothered at different times by several sources situated in or around neighbours' dwellings. Certain sub-groups of the general population are over twice as likely to be bothered as the average adult and five times as likely as low risk groups. Only a minority of those bothered took any action to remedy the situation despite the fact that two thirds wanted to reduce the noise. In general, those who took some form of action were less than satisfied with the result and 60% considered that the action had been completely ineffective. Proposals by Environmental Health Officers for ways of reducing or preventing disturbance indicate that the most effective solution will depend on the particular source of noise being considered.

Introduction

Noise from neighbours and other people nearby, now causes more widespread disturbance than any other environmental noise source. Neighbourhood noise bothers 14% of the adult population compared to 11% bothered by road trafffic noise and 7% by aircraft noise. The Building Research Establishment has undertaken a major study of neighbourhood noise disturbance based on an investigation of noise complaints made to Environmental Health Officers (1) and a questionnaire survey of a representative sample of the adult population.

The complaint data were obtained over a two year period from 1984 to 1986 using a standard data sheet. The main omnibus questionnaire survey was carried out on three occasions in 1986/87 and produced a total of over 14,000 respondents. A pilot survey and a number of in-depth interviews preceded the main survey. The questionnaire provided information on the characteristics of the sources which caused disturbance. The effect of demographic variables on the likelihood of being disturbed has been examined. The respondents also provided information on actions which they had taken to reduce the noise and on the effectiveness of such actions.

The results of the study have provided a better understanding of the nature of the problem but some further research is required to enable effective methods for reducing disturbance to be identified and evaluated.

The importance of neighbour noise as a source of disturbance is reflected by the fact that the Noise Committee of the National Society for Clean Air (NSCA) has set up a Working Group to examine the problem and to propose solutions. In order to provide further information the Working Group has sent a short questionnaire to all local authorities. Topics covered included (for the four most common sources of domestic noise complaints) the criteria used in determining whether the noise is a nuisance and steps which could be taken to remove or reduce disturbance.

Study Data

Over the two year period of the noise complaints study a total of 2,128 data sheets were submitted by 47 local authorities. These sheets dealt with 2,624 noise sources. The final sample was not closely controlled but was dependent on the particular authorities who volunteered to assist by completing and returning data sheets. Nevertheless the distribution of participating authorities over the country and between different types of authority indicates that the sample is probably representative of all domestic noise complaints.

The 'Omnimas' omnibus survey used to obtain the questionnaire survey data is carried out on a weekly basis. It uses a sample of about 2,400 respondents who are selected by multi-stage random sampling from the adult population of England, Wales and the Scottish mainland. The interviews are carried out in the respondent's home and only with respondents identified by the sampling system.

Because of the lack of information about neighbourhood noise disturbance two preliminary studies were undertaken. A pilot survey was carried out covering two consecutive weeks in November 1985. In-depth interviews were then carried out with 31 respondents selected from the pilot survey sample. The results of these studies were used in designing the questionnaire for the main survey. The main survey was undertaken for two consecutive weeks on three occasions, July and November 1986 and July 1987. A total sample of 14,406 respondents was obtained.

Results

(a) Noise sources

The distribution of noise sources from the complaints data sheets is shown in Table 1.

A sub-division of the music category showed the most frequent source descriptions to be, record player/hi-fi

Table 1 Distribution of complaints over different noise sources.

Type of source	Total mentions	Percentage of sources
Music	895	34
Dogs	856	33
Domestic activities/voices	389	15
DIY	125	5
Car repairs	73	3
Banging doors	66	3
Other animals	34	1
Domestic appliances	27	1
Other sources	158	6

(28%), amplified music (27%) and music (17%). Parties were mentioned on 88 occasions (10% of the music category).

In the Omnimas survey respondents were initially asked whether they heard and were bothered by noises from five sources, aircraft, trains, road traffic, neighbours and other people nearby. The 40% who heard noise from neighbours and/or other people nearby were then asked about disturbance from a number of specific noises. The proportions who hear and are bothered by these specific sources are shown in Figure 1. Five sources each bother around 4% of the total sample and these include the two sources, amplified music and barking dogs, which account for about two-thirds of complaints to Environmental Health Officers (EHOs). At the other end of the scale domestic appliances, though often mentioned as a possible cause of noise disturbance, only bothered 0.5% of respondents and caused 1% of complaints. About half of those bothered by any specific noise are in fact bothered by more than one source. 25% are bothered by two sources and 20% by either three or four sources. The in-depth interviews confirmed that disturbance from multiple sources occurred when neighbours had a noisy lifestyle or when there was more than one noisy neighbour.

An examination of the location of the source and the time at which disturbance occurs shows up some major differences between the five most important noise sources. Radio/TV/hi-fi is situated inside another dwelling in the large majority of cases. Noise from neighbours' vehicles, children and people's voices often arises from an open space adjacent to the respondent's dwelling. This probably explains, at least in part, why these noises are much less

important as sources of complaint to EHOs. The noise of animals is much more likely than other major sources to originate from gardens (25%). This difference was more pronounced in the case of the complaints data which indicated that 58% of complaints about barking dogs arose where the dog was outside the dwelling. Although most people who are bothered suffer the disturbance when inside their home, in over 50% of cases the noise reaches them by external transmission.

The general pattern for the variation in disturbance with time of day is that the probability of disturbance increases through the day reaching a maximum in late evening when people are trying to get to sleep. There are a number of differences from this pattern that are worth noting. The proportion of respondents bothered by noise from barking dogs was the same in all time periods while the complaint data actually indicated the daytime as the worst period. Noise from neighbours' vehicles was unlikely to cause bother during the day but was more likely to cause disturbance in the early morning. As might be expected, people were most likely to be bothered by noise from lawn mowers during the day. There seemed to be little evidence of significant disturbance arising from mowing of lawns at inappropriate times outside this period.

Respondents who were bothered by any of the specific noises (except animals) were asked whether the noise was made by adults, teenagers or children. Generally most said that the noise was made by adults and this even applied to noise from radio/TV/hi-fi where 63% blamed adults and 33% teenagers. With the exception of the specific children/teenager category only for the noise of footsteps did the proportion blaming teenagers and children approach the figure for adults. Although the proportion blaming teenagers for vehicle noise is only 36% compared to 61% blaming adults, when the smaller numbers of teenagers using vehicles are taken into account it seems that the likelihood of a vehicle user causing noise disturbance may well be greater for teenagers.

<u>(b) Demographic factors</u>

The pilot survey data have been analysed to investigate whether any particular sub-groups of the population are more or less likely to be disturbed by neighbourhood noise. A number of factors had no effect or only a minor effect on the likelihood of disturbance. These included, the sex of the respondent, his or her household status, working status and socio-economic status.

Three factors, age of respondent, tenure and type of dwelling had important effects on the incidence of disturbance from neighbourhood noise in general and from some of the specific sources in particular. For road traffic the proportion bothered increased with age to reach a peak for the 55-64 age group. The youngest age groups

were also less likely to be disturbed by aircraft noise. For neighbourhood noise the proportion bothered showed a distinct peak for the 25-34 age group and this pattern was also found with certain of the specific noises, particularly people's voices, radio/TV/hi-fi, animals and vehicles. In almost all cases the people least likely to be bothered by neighbourhood noise were those over 65.

The type of dwelling generally had only a slight effect on the proportion bothered by transportation noise though those in flats (5%) were much less likely to be be bothered by aircraft noise than those in detached houses (9%). Those living in flats were much more likely to be disturbed by neighbourhood noise than those in semi-detached and terraced houses with people in detached houses least likely to be bothered. This pattern was also observed in the complaints made to EHOs. 23% of complaints came from people living in flats although only 12% of dwellings are flats. Many of the specific sources and particularly voices, radios etc., banging doors and footsteps show a similar effect to the overall data. However there were much smaller differences between dwelling types for some sources including those such as animals, vehicles and children which are most likely to be situated outside the dwelling.

The third factor found to have an important effect on the incidence of disturbance was the type of tenure. As with the other two factors there was little effect on the incidence of bother caused by transportation noise although those in fully owned dwellings were more likely to be disturbed by road traffic noise. There was a large difference in the proportions bothered by neighbourhood noise for respondents who fully owned their own home (9%) and for those living in dwellings rented from a local authority (19%). People buying their home and those in private rented accommodation were close to the overall figure of 14% with those in the rented dwellings slightly more likely to be bothered. Again there were differences in the patterns for the various specific sources with only radios etc. and banging doors showing the same pattern as for the overall response. Noises from animals and vehicles are equally disturbing across all types of tenure. People's voices are much more likely to disturb those in the private rented sector than in the public sector where the proportion bothered is no greater than for those buying their home with a mortgage.

It is clear from the above that neighbourhood noise disturbance is not spread uniformly through the general population. There are sub-groups which have either a much higher or a much lower risk of hearing this type of noise and of being disturbed. Table 2 contrasts the data for a high risk sub-group consisting of those in the 25-34 age group who live in flats rented from a local authority and a low risk sub-group who are over 65 and live in wholly owned detached houses.

Table 2 Proportion of two sub-groups who hear and are bothered by neighbourhood noise

Noise from neighbours or other people nearby	High risk	Low risk	Overall
Percentage hear	72	16	40
Percentage bothered	34	6	14
Any specific noise			
Percentage hear	67	15	40
Percentage bothered	37	8	15

The incidence of bother in the high risk group is about five times that in the low risk group.

(c) Actions to reduce noise

Respondents were asked whether they would have liked to reduce the noises which bothered them, whether they took any action about the noise and whether any such action was effective. Overall, about two-thirds of those bothered by any specific noise wanted to try to reduce the noise. However when asked what action they had taken only 28% of respondents who were bothered had taken any action. The proportion taking action varied from 38% for radio/TV/hi-fi to only 5% for lawn mower noise.

The most commonly taken action was to complain to the neighbour or to the person responsible for the noise. 21% adopted this approach with proportions for individual sources varying from 30% for radio/TV/hi-fi to 4% for lawn mowers. The next most popular action was to complain to the local authority and this approach was adopted by 10% of those bothered. Some respondents were able to identify a particular department such as Housing or Environmental Health but the large majority mentioned the local authority in general. Other actions taken included complaining to the police (6%), taking legal action or advice (0.5%) and improving insulation (1.5%). It is clear that those bothered by neighbourhood noise may complain to either the local authority or the police without first making their disturbance known to that neighbour or to the person responsible for the noise. For noise from neighbours' vehicles, voices and footsteps, about 30% complained to the local authority but not to the person producing the noise. Vehicles and noises were also the sources (together with

children) about which people were most likely to complain to the police without first complaining to their neighbour.

When those who had taken some action were asked how effective the action had been it was found that overall only 10% considered it to have been completely effective, while a further 30% considered the action to have been partly effective. In order to permit both the effective and partly effective percentages to be used in ranking effectiveness, an Effectiveness Index EFX has been defined. The value of EFX is determined by adding half of the percentage partly effective to the percentage completely effective. Table 3 shows that some sources of disturbance are easier to control than others. Radio/TV/hi-fi was the source which could be controlled most effectively and the only source for which more than half of actions were considered at least partly effective. When the data were analysed in terms of the effectiveness of each type of action it was found that a complaint to the EHO (EFX = 36) and improved insulation (EFX = 35) were most successful. The overall effectiveness of complaints to a local authority (including EHO) was much lower (EFX = 22) than for complaints where the EHO was specifically mentioned. Legal action or advice was the least successful action (EFX = 14) with only 2% of cases being completely effective.

Table 3 Proportions of actions considered effective and ineffective for each specific noise source. The effectiveness index EFX is the sum of the percentage Completely Effective plus half the percentage Partly Effective

Source	No. of actions	Completely effective %	Partly effective %	Completely ineffective %	EFX
Radio/TV/hi-fi	450	13	42	45	34
Domestic appliances	30	20	17	63	28
People's voices	293	11	30	59	26
DIY	135	13	26	62	26
Children	286	8	29	63	23
Inside doors	181	8	29	63	23
Neighbours' vehicles	207	10	25	65	22
Outside doors	185	8	25	67	21
Animals	200	7	28	66	21
Lawn mowers	20	15	10	75	20
"Other" noises	73	6	27	67	20
Footsteps	56	7	18	75	16

Discussion

The picture of neighbourhood noise disturbance which begins to emerge is a complex one in which people are bothered by a wide variety of noise sources. A substantial proportion of those bothered are affected by multiple sources which can be situated inside an adjoining dwelling, in gardens or in open spaces near to their dwelling. While the most often cited source, radio/TV/hi-fi is almost always situated inside another dwelling, the other major sources are often found outside in gardens or open spaces.

The BRE study provides no information on the relationship between the physical characteristics of the noise and the degree of disturbance caused. Although space was provided on the complaints data sheet for noise measurements, only in a very few cases was a noise level included. In order to provide further information in this area, the NSCA survey asked EHOs to indicate what criteria they used in determining whether the noise constituted a nuisance. Responses described the factors involved, e.g. duration, loudness and time of day, but in most cases failed to quantify the factors. In the case of barking dogs, the character of the noise appeared to be important since a number of EHOs mentioned the need to obtain a tape recording of the noise for playing back in court.

Not everybody appears to be at equal risk of being disturbed by neighbourhood noise. Moreover, those who are bothered are affected to different degrees and in different ways. When asked to indicate what effect the noise had on them most mentioned annoyance or the fact that the noise got on their nerves. In terms of the effect on home life a substantial proportion mentioned sleep disturbance particularly in the case of voices, vehicles, banging doors and amplified music. For some respondents the noise may only be a minor irritation, but for others it can cause so much tension and worry that they feel it is necessary to get out of the dwelling to avoid the noise or consider it is having a serious effect on their health. In extreme cases fatalities have resulted from disputes about neighbour noise. The in-depth interviews showed that in some cases the level of noise itself did not cause concern, but rather that hearing the noise triggered concern about some other matter, for example, the welfare of a dog left unattended all day or the possibility of damage to property by children kicking a football against a fence.

It is clear that while a clear majority of those bothered would like to reduce the disturbing noise less than one third actually do anything. The in-depth study showed a marked reluctance to complain to neighbours. Reasons put forward for this included a general view that complaining would cause unpleasantness and might make matters worse. In some cases fear of a violent reaction or possible retaliation discourage people from complaining. Even when some action is taken against the noise a majority consider

such action ineffective. There are a number of possible reasons for this. Neighbours or those producing the noise may simply take no notice of a complaint (or may even respond by turning up the volume). Since many of the noise sources are intermittent it may be difficult for an EHO or the police to hear and assess the offending noise prior to taking some action. Even when a complaint achieves some reduction in the noise the problem may recur at some time in the future. Where the noise source is situated in the street or open space around dwellings the EHO will not be able to use his powers uner Section 58 of the Control of Pollution Act (COPA) and a complaint to the local authority is therefore unlikely to be effective in such situations. A particular situation for which complaints are likely to prove ineffective is where the neighbour does not make an unreasonable amount of noise but the level of sound insulation between the dwellings is poor.

The current low level of effectiveness of actions to reduce neighbourhood noise disturbance demonstrates a need for new approaches to tackle the problem. Because of its complex nature it is likely that more than one solution will be required. In many cases disturbance arises from carelessness on the part of the noise producer who may not be aware of the annoyance which he is causing. Here publicity and education will have an important role. In other cases attention to building design and to the planning of estates may help to reduce the risk of disturbance. In this context it is worth noting that in over 50% of cases the disturbing noise source is situated outside the dwelling rather than inside an adjoining dwelling. This is perhaps not surprising given the relatively low external insulation of dwellings particularly when windows are open for ventilation. For some sources it may be necessary to develop new initiatives which might use community based procedures. The development of solutions will require some further research and a study has started to investigate the problem of amplified music in more detail. The results of this study will indicate whether improved sound insulation performance could substantially solve the problem or whether the only viable solution is to persuade people to turn down the volume of their equipment.

In the NSCA survey EHOs were asked whether there were any changes which they considered would help reduce or prevent disturbance from neighbour noise generally, and from the four most important sources of complaint. As far as neighbour noise in general is concerned the list of suggestions from EHOs may be divided into six main categories:

(a) Publicity and education including codes of practice.

(b) Improved housing design included higher sound insulation and changes in the internal layout.

(c) Improved court procedures including higher fines and making magistrates' courts more responsive to private action under s59 of the Control of Pollution Act.

(d) Greater availability and use of conciliation and arbitration procedures.

(e) More manpower resources.

(f) New legislation involving, for example, noise limits on certain items of equipment and bans on certain activities.

For the specific noise sources, suggested solutions depended on the source. In the case of amplified music the main emphasis was on improved sound insulation, but for barking dogs EHOs considered that publicity and new legislation were more appropriate. The most common proposal was for a dog registration scheme with licences costing a substantial amount. Two particular aspects of dog ownership were blamed for noise disturbance, leaving the dog unattended for long periods and the presence of several dogs. A number of local authorities have already produced printed guidance on ways of preventing a dog barking in a way which would disturb neighbours.

Conclusions

(1) A survey of a nationally representative sample shows that 40% of the adult population hear neighbourhood noise and 14% are bothered by it compared to 11% who are bothered by road traffic noise.

(2) The most widespread sources of disturbance are amplified music, peoples' voices, children, barking dogs and neighbours' vehicles.

(3) Most sources which cause disturbance are situated inside a neighbour's dwelling. However some sources such as vehicles and children are more often found in open areas around dwellings. Disturbance is most likely to occur during the evening and at night.

(4) The probability of being bothered by neighbourhood noise is affected by certain demographic factors and those in the younger-mid age range living in flats rented from a local authority appear to be at the greatest risk.

(5) Less than half of those who would like to reduce the bothersome noise actually take some action. Although the most common action is to complain to the neighbour, many are reluctant to take this action because of the risk of upsetting relationships with their neighbours. Actions to

reduce noise were considered effective in only about 40% of cases.

(6) Because of the complex nature of the problem some futher work is required to aid the search for solutions. It is likely that the most effective solution will be different for different noise sources.

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References

(1) W. A. Utley and I. B. Buller 1988. Journal of Sound and Vibration, 127(2), 319-330. A study of complaints about noise from domestic premises.

DISTURBANCE FROM NEIGHBOURHOODS
A CURRENT REVIEW

By

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INTRODUCTION

Over a period of 2 years from 1984 to 1986 the Building Research Establishment undertook a major study of neighbour noise disturbance based on an investigation of noise complaints made to Environmental Health Officers and during 1986/87 a questionnaire survey of a representative sample of the adult population was undertaken by BRE.

From those activities it can be shown that noise from neighbours and other people nearby now causes more widespread disturbance than any other environmental noise source.

Neighbourhood noise bothers 14% of the adult population compared to 11% bothered by road traffic noise and 7% by aircraft noise.

STUDY DATA

Over the two year period Environmental Health Officers from 47 Local Authorities submitted a total of 2,128 data sheets. These sheets dealt with 2,624 noise sources. The questionnaire survey uses a sample of about 2,400 respondents who are selected from the adult population of England, Wales and the Scottish mainland. The interviews are carried out in the respondents' home and ONLY with the respondents identified by the sampling system.

Complaints made to Environmental Health Officers have risen alarmingly since the middle 1970's. The complaint data was obtained using a standard data sheet, the main questionnaire survey being carried out on three occasions in 1986/87 producing a total of over 14,000 respondents. The questionnaire provided information on the characteristics of the sources which cause disturbance. The respondents also provided information on the actions which they had taken to reduce the noise and the effectiveness of such action.

The importance of neighbour noise as a major source of disturbance is reflected by the fact that the Noise Committee of the National Society for Clean Air has set up a working group to examine the problem and to propose solutions. In order to provide further information the working group has sent a short questionnaire to all Local

Authorities in England, Scotland and Wales. This resulted in a response from over 270 Local Authorities.

In 1975 6,325 complaints were made about 4,793 sources of which 2,669 were considered to be noise nuisance. This arose abruptly in 1977 to 15,638 complaints rising sharply until in 1985/6 as many as 56,414 complaints were made regarding 35,636 sources of which 17,780 were considered to be nuisance. It is perhaps interesting to note that only on 8.9% of those 17,780 nuisances was an abatement notice served. The data obtained from the Institution of Environmental Health Officers does not tell us how many nuisances were actually investigated by an Environmental Health Officer or were in fact solved to the satisfaction of the complainant.

From the BRE survey, it can be seen that the distribution of sources from the compaint data is as follows.

Types of Noise Source

	%
Music	34
Dogs	33
Domestic Activities	9
Voices	6
DIY	5
Car Repairs	3
Other	10

In the survey respondents were asked whether they were disturbed as compared with just hearing the specific sources of neighbour noise. It is interesting to note that more people reported hearing people's voices, noise from children/teenagers and neighbours' vehicles than the radio/or TV. But radio or TV noise came top of the "bothered by" league, with noise from animals coming a poor 5th. Interestingly equipment such as lawnmowers were reported as being heard by a high proportion of respondents but bothered by only a few. An examination of the location of the source and the time at which disturbance occurs shows

up some major differences between the five more important noise sources.

LOCATION

Radio/TV/hi-fi is situated inside another dwelling in the majority of cases.

Noise from neighbours vehicles, children and people's voices often arises from open space adjacent to the respondents dwelling.

Animal noise is more likely from gardens not inside, eg, 58% of complaints of barking dogs are where the dog was outside.

* Although most people who are bothered suffer the disturbance when INSIDE their home, in over 50% of the cases the noise reaches them by EXTERNAL transmission.

TIME

The general patterns for the variation in disturbance with time of day show that the probability of disturbance increases through the day reaching to a maximum in late evening when people are trying to get to sleep. Most of us would have expected this phenomena but the survey has value in confirming this. As environmental health officers usually work a "normal" working day, this is presumably why many Local Authorities will not or are not able to deal effectively with complaints about neighbour noise.

There is no data available about when (ie the day of the week) complaints arise, but I suspect that a significant percentage occurs during the weekend when Environmental Health Officers are not normally working. But 3 factors did have important effects on the incidence of disturbance from neighbourhood noise in general and from some of the specific sources in particular.

1. <u>Age</u>

For road traffic the proportion bothered increased with age to reach a peak for the 55-64 age group.

The youngest age groups were also less likely to be disturbed by aircraft noise.

For neighbourhood noise the proportion bothered showed a distinct peak for the 25-34 age group and this pattern was also found with certain of the specific noises, particularly people's voices, radio/TV/hi-fi, animals. In almost all cases the people least likely to be bothered by neighbourhood noises were those over 65.

While most of us would agree that people over 65 were least likely to complain, I am surprised to find that the age group most likely to be disturbed and complain about

neighbour noise is the 25-34 group.

Respondents who were bothered by any of the specific noises (except animals) were asked whether the noise was made by adults, teenagers, or children. Generally most said that the noise was made by adults, this even applied to noise from radio/TV/hi-fi when 63% blamed adults and 33% blamed teenagers.

2. Demographic Factors

The pilot survey data has been analysed to investigate whether any particular subgroups of the population are more or less likely to be disturbed by neighbourhood noise.

A number of factors had no or minor effect on the likelihood of disturbance. These include sex of respondent; his or her household status; working status; socio-economic status.

2. Type of Dwellings

Those living in flats were much more likely to be disturbed by neighbourhood noise than in semi-detached and terrace with those living in detached houses least likely to be bothered.

Percentage of Sources Causing Complaint in types of dwelling

	Music	Dogs	Domestic	Other
Detached	15	53	-	32
Semi-end terrace	34	34	5	27
Mid-terrace	35	33	6	26
Purpose built flat	54	13	7	24
Converted flat	45	9	17	29
Percentage Overall	34	33	9	24

This pattern was also observed in complaints made to Environmental Health Officers. Where 23% of complaints were from flat dwellers even though only 12% of dwellings are flats.

3. Tenure

The third factor found to have an important effect on the incidence of disturbance was the type of tenure. There was a large difference with proportions bothered by neighbourhood noise for respondents who fully owned their own house (9%) and for those living in dwellings rented from a Local Authority (19%).

It was clear from the response that neighbourhood noise disturbance is not spread uniformly through the general population, there are sub-groups which have either a much higher or much lower risk of hearing this type of noise AND being disturbed.

The table below contrasts the data for a HIGH RISK sub-group consisting of those in the 25-34 age group who live in flats rented from a Local Authority and a LOW RISK sub-group who are over 65 and live in wholly owned detached houses. The incidences of bother in the high risk group is about five times that in the low risk group.

Noise from Neighbours	High Risk	Low Risk	Overall Risk
Percentage hear	72	16	40
Percentage bother	34	6	14

What action do people take to reduce or deal with noise problems

I suspect that if you are 6'6" tall and built like a coal miner it is a fairly easy operation to sort out the noise created by a neighbour but for the rest of us the task can be extremely difficult.

In the BRE sample respondents were asked whether:-

1. they would have liked to reduce the noises that bothered them;

2. whether they took any action;

3. whether any such action was effective.

This revealed the following figures:

	Average
Like to reduce noise	66%
Took any action	28% (5-38%)
Action effective	10%

Overall about two thirds of those bothered by any specific noise wanted to try to reduce the noise. However when asked what action they had taken only 28% had bothered to take any action - this varied from 38% for radio/TV/hi-fi noise to only 5% for lawn mower noise.

What Action did people take

The most commonly taken action was to complain to the neighbour or to the person responsible for the noise, 21% adopted this approach.

Next most popular was to complain to the Local Authority and this approach was adopted by 10% of those bothered.

Some respondents were able to identify a particular Department such as Environmental Health but the large majority mentioned the Local Authority in general. (The fact that people do not seem to know who to contact within the Local Authorities is perhaps worthy of discussion later!)

When those who had taken some action were asked how effective the action had been, it was found that overall only 10% considered it to have been completely effective. While a further 30% considered the action to have been partly effective.

Simple maths suggests therefore that 6 out of every 10 complaints are not alleviated at all. This in my opinion is too high a figure and one which every Local Authority must make very positive steps to reduce.

It may be that Local Authorities alone cannot redress the

balance but they can go a significant way towards at least carrying out a proper investigation into each complaint.

To do that they will have to put time and money into the equation. We have seen that only a small proportion of noise disturbance occurs during the normal working day. The vast majority occur at night or at weekends.

In my opinion Local Authorities must ensure that their Environmental Health Officers are working when they are needed - ie, at night and weekends. It may be that shift arrangements are required, or regular overtime, or call out systems or any number of other methods but there is no point investigating a complaint of noise at 12 noon when the nuisance occurs at 12 midnight. Money must be made available to set up such a system. Only then can this huge number of complaints be reduced and thousands of lives given some semblance of peace and quiet.

Obviously because of the complex nature of neighbourhood noise disturbance it is likely that more than one solution will be required to reduce it.

It may be that in many cases disturbance arises from the carelessness on the part of the noise producer who may not be aware of the annoyance he is creating. Here publicity and education will have an important role.

On other cases attention to building design will have a significant effect. In this context it is worth noting that in over 50% of the cases the disturbing noise source is situated outside the dwellings. This is perhaps not surprising given the relatively low external insulation of dwellings particularly when windows are open for ventilation.

Certainly better acoustic treatment should be required for flat conversions and it may be that the "deemed to satisfy" clause in the Building Regulations should be thrown away to make way for demonstrative standards.

In the NSCA survey Environmental Health Officers were asked what changes or initiatives could be suggested to help reduce or prevent disturbance from neighbour noise generally. The list may be divided into six main categories.

(a) <u>More Publicity and Education is required</u>

This may take the form of codes of practice for behaviour, or guidance notes to advise people who are disturbed by neighbourhood noise - how to complain, how to go about taking action under S.59 of COPA if that is the only way of dealing with the situation.

Many Local Authorities have their own information booklet, many based on an original from Nottingham.

The NSCA will be publishing an advice and information booklet based on best legal advice and the best of all the other Local Authorities publications. Hopefully they will be inexpensive so that Environmental Health Departments can distribute them at will. With over 56,000 complaints per year there is plenty of demand.

(b) Improved Housing Design including Higher Sound Insulation and and Changes in the Internal Layout

This is one for the architect and planner. These professionals will have to become more environmentally conscious. As an officer who attends every Planning Committee I am often disappointed at the many plans submitted which have little or no thought for those who will have to live, or work in the finished buildings. Living rooms adjacent to or on top of bedrooms, noise areas placed adjacent to quiet areas and so on. Little thought of acoustic treatment to new or converted dwellings. I suppose in this heading we could also include types of tenancies. I wonder how many noise disturbances are originally caused by a Housing Officer placing a young person or family underneath or on top of an older person or vice-versa. I well remember one situation where an Officer knowingly placed an older single man who was quite deaf and regularly played a very large electric organ underneath a young couple with small children. Needless to say the children were supposed to go to sleep whilst an organ recital resounded around their ears - and when the bottom bass notes were played the whole bedroom shook.

(c) Court procedures

Another important change required is an improvement to Court procedures. Higher fines are undoubtedly required to make people aware of the sometimes dreadful consequences of having to put up with someone's noise nuisance. Fines of £10 as handed out in Merseyside or £25 in Greater Manchester are no deterrent to anyone. West Midlands Magistrates seemed to have a better answer when in 1987 they gave average fines of £675 for the two cases found proven. Court clerks must also provide better information in general so that persons exposed to noise nuisance are not put off taking legal recourse through S.59 of COPA.

There is no reason for a person to be told he must seek legal advice from a solicitor. A person should be encouraged to take action himself or herself once proper evidence has been collated. S.59 should be a means for the court to adminster justice not to provide a healthy bank balance for the legal profession.

(d) Conciliation and arbitration

It is my view that greater availability and use of conciliation and arbitration procedures could well be one answer to the problem. Maybe some form of local noise

ombudsman or panel could be set up to deal with S.59 cases.

(e) More Manpower Resources

Many people will think that this is a typical Local Authority answer to a problem - throw money and resources at the problem and it will be solved. However, I think that becoming efficient in the investigation of noise nuisances is undoubtedly a major factor in the equation.

Environmental Health Officers are the best Officers to make a subjective view of noise nuisance. They must be available when the alleged nuisances occur. If noise nuisance occurs at night or at weekends then officers must be available at those times. It is a waste of resources not to do this.

Yes it will cost money - if Officers are required to be on call or work shifts or overtime they will require appropriate remuneration. It is good to know that many forward looking Local Authorities already have some method of achieving this marrying of nuisance time to officer availability. Other Local Authorities must follow this lead. If they do not they will, at the very least, not be providing a necessary service to the community and at worst failing to carry out a duty imposed on them by law.

(f) Legislation

Finally it is considered by Environmental Health Officer's that new legislation is required. Unfortunately they did not expand on what kind of new laws are required.

This will need further consideration, but one thing is for certain. It will be no good parliament passing new legislation without the necessary resources being made available to implement it.

It may be that noise limits may be imposed on certain items of equipment such as lawn mowers, power drills etc, or bans on the use of certain noise equipment outside certain hours similar to those encompassing ice cream chimes.

So far as dogs are concerned the most common proposal was for a dog registration scheme - the proceeds being fed back on manpower to control them.

Whatever the solution, it is a fact that in 1986 56,414 complaints were made regarding noise disturbance. By 1990 I would estimate that figure to have topped 100,000.

LOW FREQUENCY NOISE

By

Hylton Dawson
Rolls-Royce plc

The Problem

Low frequency noise is a ubiquitous problem which affects many more people than is realised - even by its victims. In spite of this, control measures are inadequate and the National Society for Clean Air must continue to press for action.

Measurement and Definition

Road transport in general, and heavy lorries in particular create great low frequency nuisance. But current EC proposals to control their noise are framed in dBA. Thus the problem will be perpetuated for the dBA scale excludes low frequencies! So, surprisingly, although life may become more comfortable outside, we will continue to suffer while indoors.

Some Common Sources

On the roads	-	heavy transport
On the waterways	-	ships
In the air	-	helicopters and airships
In the office	-	ventilation and air conditioning
On construction sites	-	compressors and heavy plant
In the pub	-	residual din from the disco
On the railways	-	diesel locomotives

Controls

Various controls which involve measurement, definition, regulation and various means of silencing will be discussed and the paper will suggest courses of action for the layman, the environmental health officer and the acoustician.

Low Frequency Noise

Since the specific problem of low frequency noise was first discussed during the 48th Annual Conference of the National Society for Clean Air in 1981, there has been much debate on the topic. But regrettably, although there has been scattered action, little has been done to tackle the problem on a broad national or international front. What has happened however is that publicity, engendered by the 1981 Conference, has made this Society a focus for comments, complaints and requests for help. Staff at our Brighton

headquarters have, as usual, undertaken the attendant work with energy and enthusiasm, and long suffering members of the public throughout the United Kingdom have expressed their appreciation of this Society's efforts. It seems timely therefore to remind ourselves of the human and technical problems, what still needs to be done about them and to suggest courses of action in which we can all play our part.

Definitions

Noise - or Vibration?

Those who are troubled by low frequency phenomena often refer to 'the vibration'. Indeed, when their problems are investigated some vibration is usually present. But generally this vibration is a secondary effect caused by building structures, furniture or fittings responding to excitation by an airborne sound wave. Even quite close to powerful sources of low frequency noise, the incident sound energy tends to exceed vibration energy by a factor of thirty to one. So what is referred to herein and what causes the widespread problems described are simply airborne sound waves.

Low Frequency

Given sufficient sound intensity, it is possible to hear low frequency noise even at frequencies as low as 1 Hz. Below about 16 Hz however, it loses its tonal quality and is more often detected as a series of events. But because the human ear is quite insensitive at these very low frequencies, it would require massive noise sources to produce sufficient intensity to cause significant problems. Fortunately, such cases are rare.

Somewhat arbitrarily, the lower frequency limit of human hearing under everyday conditions is taken as 20 Hz and the (largely unheard) frequencies below this come under the generic classification of Infrasonics.

The low frequencies which are considered in this paper therefore fall between a lower limit of 20 Hz and an equally arbitrary upper limit of 261 Hz. The upper limit is chosen simply because it is well known - being middle C on the International Concert Pitch scale - while subjectively manifesting itself as still rather a low pitched sound.

Within this range, those frequencies between 20 and 90 Hz are of considerable interest whilst those around 40 Hz are (again somewhat arbitrarily) taken as paramount.

The People Problem

What do they feel?

The problem under consideration is the fact that, for

whatever reason, some people are made to feel disturbed, upset, annoyed, wretched or ill when subjected to relatively low levels of airborne noise in the range we have chosen to define as 'low frequencies'.

Well observed manifestations of the low frequency sensitivity syndrome have been noted as:

- Feelings of irritation, unease, fatigue
- Headache
- Nausea
- Vomiting
- Heart Palpitations
- Disorientation
- Swooning/Prostration
- Pains in the neck, arms, legs, digestive disorders and disturbed sleep.

Is exposure to low-level, low-frequency noise harmful?

The general opinion expressed by the medical profession is that there is no conclusive evidence that low-level low frequency noise is in itself directly harmful to people. But the symptoms noted are those commonly associated with stress. Therefore, exposure to such noise is thought to be an added stress factor and the reactions will, of course, depend on each individual's susceptibility.

What is unarguable is the fact that for sensitive people there are considerable adverse effects on their quality of life. Interestingly enough, it has been noted that for people who do not regard themselves as sensitive, cessation of low frequency noise to which they have been exposed brings a sensation of noticeable and, in some cases, overwhelming relief!

What do they hear?

Surprisingly many people are not too sure about what exactly they hear when exposed to low frequency noise. Because it is often at quite low level and contains no obvious tones, they may not readily associate their sensations with noise. It is quite common for people to feel unduly tired after several hours exposure to poorly silenced ventilation systems in offices or lecture rooms without in any way correlating their feelings with a noise which they did not notice because 'it is always there' or 'they have got used to it'.

Others will talk about the vibrations which it is not, while others will describe a hum, a thump, a rumble or simply a disturbance.

Whatever is heard or felt by some, there are others who either do not hear - or if they do - never react in any visible way to low frequency noise. Some of these are likely to display quite robust attitudes to those who

suffer. So why should there be a great number of apparently sensitive souls?

Individual Sensitivity

In the use of any of the senses, reactions range from sensitive through normal to insensitive. Hearing is, of course, no exception but in the area of low frequency noise special factors operate.

Scientific research on hearing sensitivity and the associated subjective sensations throughout the entire range of audible frequencies has given rise to the internationally accepted equal-loudness and equal-annoyance contours.

Both the equal-loudness and the equal-annoyance curves are plotted in the mid range - about 1000 Hz - at 10 dB intervals from the just audible to the intolerable - a range of about 120 dB. But at low frequencies both the equal-loudness and equal-annoyance contours converge into a very small compass. This clearly demonstrates that there is a very small range of noise levels between what is inaudible and what is intolerable.

Given the known variation in sensitivity of hearing among the general population, it follows that a low frequency sound which is quite inaudible to one person, may well be loud and distressing to another.

But there is yet more to this phenomenon of sensitivity.

Given a long enough period of exposure, most sounds cease to be an overt problem because people become used to them, learning to adapt and not pay attention to them. But in the case of low frequencies many sensitive people report that they appear to tune-in to the noise and that its loudness actually appears 'to grow'. Further, it has been demonstrated that this tuning-in can increase an individual's sensitivity by 7 dB. But a sensitivity increase of only 5 dB could double the apparent loudness of the sound which is heard. So it is not surprising that some people suffer to an extent whereby stress symptoms are displayed. It is a matter of regret that this explanation, although plausible, will bring little comfort to those who suffer. But let us hope it can at least engender real sympathy for them.

The Indoor Effect

Another unfortunate effect of low frequency noise is that those who are affected by it may not find relief if they flee indoors. Indeed, the converse is often true.

The annoyance caused by any sound is related in a very complex manner to its character, the information which it contains, apparent loudness and how it is processed by any particular individual. But because of our hearing

responses, low frequency sounds may be readily 'masked' by those higher frequencies to which we are more sensitive.

So in the open air other noise such as say urban traffic din may well mask some annoying low frequencies.

But the attenuation of any building structure increases by about 5 dB with each doubling of sound frequency. Thus, when we go indoors the middle and high frequency noise (din) will be greatly reduced while the low frequency levels may be unaltered, or even increased by room resonances. So we may face the apparently absurd situation where the dBA levels have been reduced, but the sensation of loudness or annoyance has actually increased.

The problem may be yet further exacerbated by the fact that low frequency noise from any source is less directional, and less affected by air-absorption and ground scattering than higher frequencies. It thus travels much further and can give rise to puzzling noise problems in what would otherwise be regarded as quiet locations.

Sleep

Low frequency is bad enough when you are awake - but sleep disturbance is often quoted by those who report low frequency noise problems. It has been demonstrated that a person is more likely to be brought out of the rapid eye movement (REM) phase of sleep by low frequencies than by any other type of noise.

While we sleep our brains are constantly processing noise information, but the characteristics of low frequency sound are such as to reduce the ability of the brain to process it and still maintain the REM state of sleep.

In the frequency range 2 - 90 Hz, sleep-disturbance effects have been observed at sound pressure levels as low as 65 dB.

Characteristic complaints of sleep disturbance are that the complainant is awoken by something unknown, but then becomes aware of 'a vibration' which rattles furniture and fittings in the room and suffers sensations described as 'oppressive' or 'heavy'.

Control

Apart from any technical difficulty involved in the control of low frequency noise, the operational demands are greater than for higher frequencies, for they dictate two-fold objectives.

Firstly, the need is to reduce noise levels such that they do not in themselves cause distress to people. But also they must be controlled to an extent that they cannot induce significant vibration in buildings, furniture and fittings which may in itself give rise to annoying secondary problems such as rattles and squeaks.

Currently, there is little scientific information on which to base control criteria but anecdotal evidence points to some valuable pragmatic guidelines.

These are quite simply:

For broad band noise lacking any tonal character -

Prevention of Annoyance

Control Frequencies

Base control on the octave band centred on 31.5 Hz.

The justification for this is that normal ear response is such that lower frequencies would need to be at much higher levels to cause equal or greater annoyance. Higher frequencies, if important, would reveal themselves by the character of the noise.

Control Levels

In any residential/office situation expect the following reactions:

Sound Pressure Level (SPL) is 31.5 Hz Octave Band measured on the facade of the building in question

<75 dB re 2×10^{-5} N/m^2	Reasonable complaint unlikely
>75 dB <85 dB	Complaints possible but very dependant upon individual susceptibility
>85 dB	Complaint likely

In any sleeping room expect some complaint of sleep disturbance if SPL in 31.5 Hz band exceeds 65 dB re 2×10^{-5} N/m^2.

Limitation of Secondary Vibrations

Control Frequencies

Base controls on the octave band centred on 31.5 Hz

Control Level

At the facade of the nearest noise-sensitive premises maintain the octave band SPL below 75 dB re 2×10^{-5} N/m^2.

Note: If any significant infrasonic energy is present, further control may be necessary.

Measurement Units

The above empirical criteria do not make easy reading due to

the fact that we still lack a suitable measurement unit to describe low frequency parameters. This precisely mirrors the case in earlier years before the use of the ubiquitous dBA was widely adapted as a simple measure for ordinary din.

Arguably, it is the success of the dBA which has led to some of our current problems with low frequency noise. As a unit, it quite adequately describes a wide range of subjective effects, and is understood by both specialists and laymen. This has led to its use in most of the existing and projected noise control regulations for plant and vehicles. But the dBA virtually discounts all low frequency noise which in consequence has been generally ignored. So for instance, while transport vehicles cause widespread problems, EC proposals to limit their din and which are framed in terms of dBA will do nothing to curb low frequency emissions.

Common Sources of Low Frequency Noise

There is much for this Society to do in alleviating the current problems which are so widespread that it is only possible to give an indication of their scope. But they do include such facts as:

Outside

Heavy Transport

The diesel engine, as fitted to lorries, buses, locomotives, ships and barges, already causes concern to the NSCA because of gaseous and particulate emissions. But these vehicles are all potent noise sources. Buses in particular, because they regularly use fixed stopping places, are a major source of annoyance as has been shown in numerous attitude surveys.

Ships and Barges

These do not cause such widespread problems as road and rail transport but there is considerable scope for control and improvement.

Light Railways

The light railway is coming back into its own as a form of urban transport. But space limitation often demands that the track be built on elevated sections. The associated metalwork will readily radiate low frequency noise.

Airships

Airships increase in popularity both for utility and pleasure. But those who dwell beneath regular flight paths are daily becoming less tolerant of the new noise source which afflicts them.

Helicopters

As congestion in city streets and urban motorways increases, the helicopter, although expensive to operate, becomes a more commercially attractive transport option. But offices and residential areas in central London are now raising objections to the noise.

Less frequently, but arguably with greater impact, the tranquillity of rural life is being shattered by the din which results when friends of the people next door literally drop-in for Sunday lunch.

Industrial, Construction and Agricultural Plant

Agricultural plant is becoming bigger so that those operating them can take advantage of economies of scale. But in low ambient noise, the low frequencies are intrusive over considerable distances.

Heavy construction plant and air compressors also cause significant problems.

Residual Thump from Loudspeakers

Places of Entertainment

In places of entertainment such as public houses, clubs and discotheques, amplified music is reproduced at high level through loudspeakers which have excellent base response characteristics. Although most reasonable building structures effectively contain this din (which can be about 100 dBA), they readily transmit low frequencies. So adjoining properties in particular, and the neighbourhood in general, are subjected to an annoying residual thump.

The Neighbours

The same problem occurs in linked houses or multi-occupancy dwellings when domestic hi-fi equipment is played at high volume. It leads to endless friction between neighbours. It is interesting to note that in a recent survey of what would be considerable desirable features in a new dwelling, the majority of people wanted a cellar and internal walls constructed of masonry rather than studding!

There is an obvious need for adequate standards of low frequency sound insulation, but it may also help if people were educated to provide vibration isolation for loudspeaker mountings which are affixed to party walls.

Protecting People from Low Frequency Noise

Sound Proofing Affected Buildings

It is much more difficult to protect people from low frequency noise than from everyday din. Not only do low

frequency pressure waves travel further, but they are much less directional and so cover a wider area. Many building structures do not provide much attenuation and indeed some lightweight modern buldings may provide virtually no protection at all. Large plate glass windows which feature so prominently may cut out normal traffic noise, but their vibration characteristics are such that they very efficiently radiate low frequencies into the building concerned. So trying to solve problems by acoustic treatment of those buildings where people are disturbed is an unattractive and expensive option which does nothing to remove the root cause.

Sound Proofing the Noise Source

If problems do occur, a much better option is to enclose the noise source in a structure which is designed to give the necessary noise reduction. Usually this is quite expensive and difficult because it requires a combination of massive structures - to provide the necessary sound transmision loss - and very thick sound absorption to control reverberation. But it can be done and when successful, protects everyone in the vicinity.

Eliminating the Noise at Source

By far the most attractive option is to eliminate the noise at source, but this will only become universal practice when the necessary control standards have been evolved and silence becomes a design parameter. The acoustic technology already exists, but currently it tends to be ignored. Good engineering design and built-in acoustic treatment could substantially reduce much of the noise generated by heavy machinery while residual low frequencies may well prove amenable to new techniques such as active noise suppression.

The Concept of Inaudibility

In considering what noise standards are suitable for various situations and activities, acousticians are now postulating, somewhat boldly, the concept of inaudibility. Many forms of noise have some use in that they give warning, information or even pleasure. But as low frequencies provide none of these, but are merely a nuisance, inaudibility would appear to be a desirable objective.

So what should we be doing?

All those concerned with the National Society for Clean Air can play a useful role in controlling the problems due to low frequence noise.

We must: -

ENSURE that the problem, while being kept in perspective, is recognised as a real and important constraint on the quality of many people's lives.

DEMONSTRATE awareness and consideration for those who suffer from what may only affect us to a lesser extent if at all. In becoming aware we may well be surprised, for undue low frequency noise will be evident in homes, offices, concert hall, lecture theatres, hospitals and recreational facilities. The problem is one of disturbance rather than din.

PLAN for low noise. Recognising that current standards and noise measurement units ignore the existence of low frequencies, planning standards should be framed to specifically take account of the problems. To this end there is scope for useful educational interchange between the Environmental Health Officers and the planners. Local initiatives have already proved effective.

NEGOTIATE for changes in, or addition to, recognised noise standards. The dBA unit and the widely accepted Noise Rating (NR) or Noise Criterion (NC) curves all ignore low frequencies. The Society's Noise Committee will doubtless take action in this matter.

PRESS for legislation to effectively control both low frequency and infrasonic noise emission.

Concerted action will eventually lead to a political and financial climate in which engineers and scientists can use their talents to the advantage of all. Improved design, better silencing, active noise suppression, and convenient measurement unit will all play their part in controlling the problems which we associate with low frequency noise.

PRACTICAL MEASURES TO REDUCE THE EFFECT OF TRAFFIC NOISE

By

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In examining transport statistics, whether these relate to the number of vehicles registered, the number of vehicle-miles travelled or the miles of new roads constructed, the conclusion is always the same - traffic is continuing to grow and to spread ever more into previously quiet parts of the country. Since 1980 traffic in the UK has increased by 35% and the number of vehicles on the roads has increased from 20 to 23 million. Traffic is also encroaching into previously quiet periods of the day, as day-time congestion encourages both commuter and long-distance drivers to try early mornings and late evenings for their journeys.

Traffic predictions for the future indicate further substantial growth, particularly with respect to the distances covered by goods vehicles (1). Between 1988 and 2025 total vehicle-miles are expected to rise by between 83 and 142%. Light goods vehicles, i.e. those most likely to affect the urban environment, are anticipated to increase their vehicle miles by between 101 and 215%. In considering these predictions it should be remembered that in 1983 traffic had been expected to grow by between 9 and 16% by 1988 whereas in fact the actual figure was 27%. The new forecasts claim to take a more optimistic view of future economic growth and are therefore perhaps less likely to repeat a similar underestimate. To meet the anticipated growth in the volume of road traffic, the Government is proposing to add over 2,700 miles of new or widened roads to the trunk road network.

The problem, of course, is not unique to Britain and in the OECD countries in Europe the number of private cars increased from about 64 million in 1970 to 122 million in 1985 (2), while the number of goods vehicles increased from 8.3 to 13.2 million over the same period. To meet the extra traffic the European motorway network increased during that time from 14,500 to 33,500 kms.

Improving and extending the trunk road network does not necessarily improve the situation in towns and cities, and the extra volume of traffic on Britain's inter-urban roads will, to a large extent, at some stage find its way into residential, commercial and other noise sensitive areas. As well as inter-urban road traffic, there is also a steady

increase in traffic within towns and neighbourhoods, and from an environmental point of view this is potentially even more serious. The change in shopping patterns, away from local shops and towards supermarkets, hypermarkets and shopping malls necessitates increasing car usage, much of it on roads with previously light traffic. Similarly there is now a substantial amount of local traffic, often congested, associated with the start and finish of the school day, emitting noise and pollutants to those most likely to be harmed by them.

To protect the environment the growth in traffic must not lead to a corresponding growth in noise disturbance, and as far as possible the problem must be prevented before it needs to be cured. Reducing the effects of traffic noise can be tackled at various levels, but by far the most effective in reducing not only noise but also pollution is to reduce the demand, and the need for increased road transport, whether for carrying passengers or freight. By the development of a transport policy, associated with appropriate financial incentives and disincentives, aimed at encouraging the use of public transport and the use of rail rather than road for long distance freight traffic, the increase in the volume of traffic on the road should at least be slowed.

It must be admitted, however, that even if a policy to contain or even reduce the amount of road traffic were implemented, and at present there is no indication that this is likely, there would still be substantial pollution and noise problems attributable to vehicles on the road. This paper endeavours to outline some of the practical steps which can be taken to minimise the noise problem.

PREVENTION

In noise control, as in many other fields, it is true to say that prevention is better than cure, and moreover in many cases it is also cheaper. Noise of course cannot be completely prevented, but much can be done to minimise its effects both by reducing the noise at source and by using planning and design to protect those who could be exposed to it.

Reduction at Source - The Vehicle

In recent years a great deal of progress has been made in the reduction of vehicle noise and in Britain this is mostly due to a progressive tightening of EEC noise limits, rather than any lead taken by the government or industry. Unfortunately a manufacturer's claim that his vehicle or motorcycle is quieter than that of his competitors is not recognised as being a major selling point, and the manufacturer would have to be very altruistic to bear any additional costs of noise research or actual noise reduction unless he is persuaded to do so by legislation, and knows that his competitors are similarly affected. In 1980 an

OECD conference on Noise Abatement (3) proposed that noise limits for new motor vehicles should be reduced by between 5 and 10 dB(A) depending on type, and that this new limit should come into force between 1985 and 1990. The conference considered that technology was already available to achieve these reductions at reasonable cost.

As an example the OECD quoted proposed German limits of 75 dB(A) for cars and 80 dB(A) for heavy lorries and buses by 1985. In practice this target has been sadly missed and the latest EEC Directive 84/424 sets emission limits of only 77 dB(A) for cars and up to 84 dB(A) for heavy lorries. These limits for new models of heavy lorries have only just come into force (October 1989) and will apply only to new vehicles from October 1990. This means it will be only about the year 2000 before the great majority of all vehicles on the road will comply with even modest standards. Research on reducing lorry noise is however continuing and the QHV 90 project (Quiet Heavy Vehicle) at the Transport and Road Research Laboratory shows that quieter heavy commercial vehicles are possible.

As far as motorcycles are concerned there is no technical problem in appreciably reducing the noise of even the most powerful models. Proposed limits for 1993 are 2 dB(A) below the present levels of 77 dB(A) for motorcycles of less than 80cc and 82 dB(A) for those over 175cc (4). The problem is more of ensuring that exhaust mufflers remain effective in use and are not deliberately tampered with by motorcyclists with the mistaken impression that noise equals power. Recent regulations in this country that replacement silencers have to meet approved standards will help to reduce problems associated with certain types of 'silencers' which were advertised for their 'roar' rather than their effectiveness.

Reduction at Source - The Road

It has to be recognised that motor vehicles cannot be completely silenced, and for the forseeable future, even with improved noise limits for newly constructed vehicles, the levels of traffic noise cannot be appreciably reduced, by dealing only with the vehicle. In some situations, potential future noise problems can be prevented by the simplest and most obvious of all means - separation of noise source and listener. By taking noise levels into account in route planning, and selecting routes which as far as possible avoid noise sensitive areas, run alongside existing railway lines, pass through areas due for early re-development or can take advantage of natural topographical features, many problems can be avoided.

Many methods have been developed since the days of the Urban Motorway Committee (5) and the later Jefferson Report, to enable objective assessments and comparisons to be made between various route options, and one of the factors to be taken into account is of course noise, both with respect to

changes in level and the numbers of people affected. Since July of last year environmental assessments of new motorway schemes have in fact become mandatory as a result of an EEC Directive (6).

Route selection alone is not always the complete answer in a real life situation, and the next stage is road design. Again it is clear that a road in cut (or ideally even in tunnel) is to be preferred to one at grade or elevated, but cost must also be considered. In doing so however the balancing factor of lower compensation costs under the terms of the Land Compensation Act 1973 and fewer houses requiring insulation under the Noise Insulation Regulations 1975 must also be taken into account. In terms of noise level, elevated roads can be environmentally very damaging but by the use of noise barriers this can, to a large extent, be minimised.

Noise barriers incorporated at the design stage are often more effective, more aesthetically acceptable and cheaper than if they are added as an afterthought. Barriers are most useful in protecting low rise dwellings near elevated trunk roads, and their effectiveness depends on their height, their proximity to the noise source and their length. Their mass is relatively unimportant as the limiting factor is nearly always their height rather than the transmission of sound through them. In many instances solid timber or even fencing without any gaps will be as effective as concrete for this purpose. (7)

Even roads in cut can present problems if there are houses close to the edges, and solutions include sound absorbant surfaces on retaining walls to minimise reflection, and partial overhanging barriers as along sections of the Boulevard Peripherique in Paris. Recent work in Germany and Austria has also led to the introduction of permeable asphalt road surfaces which can give a reduction of 3 or 4 decibels in tyre noise without reducing safety. The topic of tyre/road noise is in fact becoming increasingly important as engine noise is reduced, and in August 1990 an international conference will be devoted to it.

The use of planting by itself has relatively little effect in reducing noise, unless it is done in considerable depth. It can however be used in conjunction with other barriers to improve their appearance, and reduce sound reflections. There is some evidence however that the visual screening produced by tress and shrubs, even if it does not give real noise reductions to any extent, does have a useful psychological effect in reducing annoyance due to traffic.

Prevention by Planning and Design

The onus on noise prevention should be, and usually is, primarily on the noise producer, but those responsible for planning, lay-out and design in the vicinity of an existing or proposed highway must also take responsibility for

minimising the effects of transport on those living or working in the locality.

Most aspects of noise planning are merely an application of common sense, and on a 'green field' site, if noise is taken into account from the beginning, its effects can be greatly reduced. The use of distance by itself is often not practicable, due to high land values, particularly near busy roads. Noise from individual vehicles reduces by about 6 decibels for each doubling of distance, and that from the traffic stream as a whole by about 3 decibels for each doubling. Thus, in the close vicinity of the road, additional distance does give benefits, but as one moves further away the law of diminishing returns becomes operative, and the improvement for, say, each additional hundred metres, becomes less. However, the sound of individual vehicles will tend to merge more into that of the traffic stream as a whole.

More practical means of reducing noise are the use of non-noise sensitive buildings such as garages, warehouses, light industry or even air conditioned office blocks as screens for dwellings, schools or hospitals set further back. Where this is not possible, and dwellings have to be located near the highway, they need to be designed to reduce the effect of noise on their own occupants, and can then themselves be used to screen other dwellings set further back as well as open spaces between them. There are many design possibilities for such exposed residential blocks, the best being the use of single-aspect design, where access balconies, kitchens and bathrooms face towards the highway, and living rooms and bedrooms face away. Other designs where effectiveness depends on local conditions and topography include patios and 'stepped' blocks with lower floors shielding those higher up.

A last resort, and the least desirable solution, is the use of sound insulation, usually double windows with at least a 100mm air space between them. This can be very effective but requires artificial ventilation if it is to be of practical value, thus incurring costs. Again however sound insulation incorporated in the design of a new building is very much more effective and cheaper than if added later as a remedial measure. There are no estimates for additional insulation costs in the UK, but German estimates suggest that insulating new housing can add 0.5 to 2.2% (in extreme cases) to construction costs. (8)

Living in a flat or house where windows have to be kept permanently closed, however good the artificial ventilation, can scarcely be considered desirable, and the importance of reasonable noise levels in gardens must also not be overlooked.

NOISE REDUCTION IN TOWNS

Urban Motorways

In existing towns and cities the scope for preventing noise problems is rather limited, and in most cases the need is to cure or at least reduce already existing noise conflicts. Perhaps surprisingly, and certainly controversially, one of the potentially most serious noise sources, the urban motorway, can also be used to reduce the noise and pollution for an area considered as a whole. In existing situations, with through traffic, including heavy lorries, trying to find ever new routes through urban areas, and creating rat-runs in an effort to beat congested roads, many residential roads not designed to carry such traffic are exposed to high pollution and noise levels.

If new roads or urban motorways can be used to reduce traffic in residential roads an appreciable net benefit can be obtained, providing of course that the route of the new road is carefully chosen. Along the new road itself noise levels will clearly rise, but if the route avoids heavily populated areas and is designed to minimise noise, far more people will benefit from reduced noise levels in most cases, than will be exposed to increased levels.

This is also true if a road already exists and is upgraded to take additional traffic. Increasing traffic volumes by 25% increases noise levels by only 1 dB(A) which is imperceptible and even a doubling of volume gives an only just noticeable 3 db(A) providing speed and traffic composition remain the same. To reach a doubling of perceived loudness, traffic volumes would have to be increased ten fold. Two points however must be considered. Firstly even a small increase in noise is undesirable, and people heavily exposed to such an increase for the benefit of others must be compensated. The Land Compensation Act 1973 and the Noise Insulation Regulations 1975 provide for such compensation on the condition that the increased level is at least 68 dB(A), averaged over the period 0600 to 2400 hrs, that there is at least a 1 dB(A) increase, and that this is due to some physical alteration to the road. The second point is to ensure that the road improvement does not merely lead to an overall increase in traffic, bringing the situation in minor roads back to what it was before.

Lorry Bans and Restrictions

A UK social survey published in 1978 (9) found that 12% of those interviewed were very much, or quite a lot, bothered by lorry noise, and 22% bothered to some extent. Of those who actually mentioned hearing lorry noise, 33% were bothered by it. In both cases, slightly higher percentages were bothered by motorcycle noise. On the other hand, when asked what sort of vehicles made the worst noise, 39% mentioned lorries, 19% motorcycles and mopeds, 5% mentioned buses and coaches and 4% mentioned cars. The reaction of

people to commercial vehicles is also shown from a table in a study carried out by the Building Research Establishment (10) which indicates that while 68% of people hearing unspecified road traffic noise are bothered by it, in the case of trucks and buses this rises to 83%. This study in fact suggested that under non-freely flowing traffic conditions, the most useful prediction of noise nuisance is related to the logarithm of the percentage of heavy vehicles in the traffic stream rather than to any measurement of traffic noise using existing noise units.

Some lorry movement in urban centres is essential, but much through traffic can be diverted and disturbance reduced by restrictions on lorry movements particularly at night. The noise level from a traffic stream depends on the total volume, the average speed, and on the percentage of heavy vehicles, the latter being the most critical. If all lorries are removed from one traffic stream and diverted to one where there is already a high percentage of commercial vehicles, this can lead to a marked improvement in noise levels on the first road, with only a slight increase in the other.

Apart from the problem of lorries in a traffic stream, an equally or even more important problem in cities relates to individual lorries and other noisy vehicles, including motorcycles, in quiet residential roads particularly at night. Individual heavy lorries taking short cuts through residential streets at night can lead to many people having their night's sleep disturbed. These problems and possible solutions have long been a matter of concern in London.

To discourage rat-runs and the unnecessary passage of heavy commercial vehicles though noise sensitive areas much can be done by the use of traffic signs and physical width barriers. In many parts of London for example there are now signs prohibiting the overnight parking of lorries, so as to avoid the problem of lorries revving up their engines very early in the morning in residential roads and waking up neighbours. To make this effective, accessible lorry parks have to be provided and located so as not themselves to cause a nuisance. Low speed limits also reduce noise, particularly of cars, and this approach, associated with roads designed to substantially slow down vehicles, is now widely used in Germany and Holland to reduce not only noise but also accidents in small residential areas. Physical width restrictions are becoming increasingly common in Britain and effectively reduce the passage of lorries and heavy vehicles through areas where they have no business. Some barriers make provision for buses to pass through, with the bus passage marked to exlude other vehicles, and of course there are always facilities for emergency vehicles.

To protect large areas or whole towns different methods have however to be used, and these must recognise both that the lorry is essential to the life of the city, and also that it creates the most serious noise problem.

The problem of lorry traffic was considered in detail at a Public Enquiry set up by the Greater London Council in 1983 and noise was one of the main topics discussed (11). One argument put forward against a ban on heavy lorries was that these would be replaced by a larger number of smaller lorries, just below the weight limit set for the banned lorries, so as to be able to carry the same total load. The extent of this was difficult to quantify, but some tentative calculations based on certain assumptions were made. For example, one estimate was based on a traffic flow of 3,000 vehicles per hour, at 40 km/hour, with 20% heavy lorries. Assuming a 50% increase in the number of lorries (i.e. from 600 to 900) with the smaller lorries still having the same noise characteristics as the bigger ones, the increase in noise level would be 1 dB(A) (imperceptible). On the other hand, if the large lorries were replaced by even four times the number of vans, having quieter noise characteristics similar to those of cars, noise levels would actually decrease by 3.5 dB(A). Even on the unlikely basis of a 10.1 replacement rate, there would still be a 1 dB(A) reduction.

As a result of the Inquiry a night-time and weekend lorry ban was introduced by the GLC shortly before its abolition in 1986. The lorry ban remains, however, and is now administered by the London Boroughs Transport Scheme. Its effectiveness is being monitored by before-and-after surveys in some areas. The ban affects lorries over 16.5 tonnes and operates from 2100 hrs to 0700 hrs each night, and from 1300 hrs on Saturday to 0700 hrs on Monday. The ban does not apply to specified trunk roads and access roads, and many individual lorries are exempt because they are used to carry essential goods or because they meet certain noise criteria. Manufacturers and distributors have been very co-operative in developing and testing methods of reducing noise from their vehicles and thus make them exempt from the ban. Special hush-kits to reduce noise of existing lorries have been designed. Lorries permitted to use roads during the restricted periods must carry an Exemption Plate and display a renewable Permit on their windscreens.

Traffic Management Schemes

As mentioned earlier a doubling or halving of traffic volumes causes a just noticeable change of 3 dB(A) and this applies equally to a change between 200 and 400 vehicles, or between 2000 and 4000 vehicles. It would need a ten-fold change to give a doubling or halving perceived loudness.

In practice this means that at low traffic volumes, a few hundred extra vehicles can make a great deal of difference to the noise climate, whereas at high traffic flows they would have a negligible effect. These facts have important bearings on the environmental implications of traffic management schemes.

The primary purpose of traffic management schemes is to improve traffic flows, but their introduction can also have

an important effect on environmental noise levels. Splitting a traffic flow on one road into two equal parts leads to a scarcely noticeable reduction in the first road but often a sharp increase in the other. For example if a traffic management scheme is introduced by making the main road one-way, and designating a road parallel to it to carry the reverse flow, the average flow in the main road will be halved, giving a reduction of 3 dB(A). In the parallel road, which may previously have carried only very light traffic, the average traffic volume will rise to the same level as that in the major road, giving an increase of perhaps 20 dB(A) or more. Consequently, if the roads are similar, twice as many people will be affeted by high noise levels as before. If the road used for the diverted traffic is narrower and not designed to carry high volumes, the effect is accentuated. Furthermore if the scheme is successful from the traffic point of view, it is likely to lead to an overall increase in the total volume of traffic in the area, as well as an increase in speed, thus raising noise levels still further.

Traffic management can however also be used to improve the environment for an area taken as a whole. Concentrating traffic on to suitable main roads and reducing rat-runs can lead to substantial relief in residential roads. Using only main roads for one-way schemes could involve establishing complementary traffic schemes some distance apart with increased driving distances for through traffic, but would be environmentally beneficial.

In London, environmental assessments of proposed traffic management schemes are usually undertaken before their final implementation. These include theoretical predictions of changes in noise levels and estimates of numbers of people affected either beneficially or otherwise, followed by before-and-after measurements of actual noise levels. Similar assessments are usually also made of changes in levels of pollution. Thus, by the use of predictive techniques, and experience based on actual measurements, traffic management schemes can be used to improve the local environment, or at least designed so as to minimise any adverse effects for the majority of the local population.

National Policy

Much can be done at local level to reduce the effect of traffic noise but the ultimate responsibility, and the biggest improvement can be gained by action at the national level. However much effort is devoted to planning, route selection, road design, traffic management, vehicle noise reduction and sound insulation the benefits can soon be overtaken by continuous growth in traffic volumes and the consequent pressure for yet more roads to relieve the congestion.

While the ownership of private cars is a great boon, the necessity to rely on them because of poor or excessively

expensive public transport is not. Similarly the provision of company cars and a system of taxation which encourages the maximum mileage for these cars, rather than providing for the provision of tax deductible season tickets helps to ensure the continuing growth in traffic demand.

Providing more bus lanes in cities and ensuring that they are effective by better policing, would speed up public transport and encourage its use. Encouraging car sharing or pooling for home to office journeys by the provision on highways of special lanes only available to vehicles carrying three or more passengers as in Los Angeles, would also help to reduce noise, pollution, accidents and energy use.

On long distance routes the transportation of freight by rail, and the provision of adequate rail/road transfer yards could do much to reduce heavy lorry traffic but it would need government encouragement in a practical form for this to happen.

Finally, Britain could follow the example of many countries in Europe by providing more cycle tracks in cities, which would not only reduce noise and pollution, but would also lead to a fitter population!

1. Roads for Prosperity, Department of Transport Cm 693, May 1989

2. Transport and the Environment, OECD 1988

3. Conference on Noise Abatement Policies, OECD Paris, May 1980

4. Council Directive 87/56/EEC, Official Journal No. L24, 1987

5. Report to the Urban Motorways Committee, Department of the Environment, 1973

6. Council Directive 85/337/EEC and Town and Country Planning (Assessment of Environmental Effects) Regulations 1988, Stat. Inst. 1199

7. W. E. Scholes et al, Performance of a Motorway Noise Barrier at Heston, Applied Acoustics 1974

8. Fighting Noise - Strengthening Noise Abatement Policies, OECD 1986

9. Road Traffic and the Environment, J. Morton Williams et al, SCPR 1978

10. Noise Nuisance Caused by Traffic in Residential Areas, J. Langdon, Journal of Sound and Vibration, Vol 47.2, July 1976

11. Heavy Lorries in London, Report of Panel of Inquiry, Chairman Derek Woods QC, June 1983

THE FUTURE FOR LANDFILL

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Introduction

To prejudice the arguments which I have followed in this paper, let me commence with a statement which I hope is a statement of the obvious; that landfill is certain to continue to fulfil a major role in the disposal of controlled wastes in general, notwithstanding the problems with which it is increasingly perceived as being beset. Despite waste minimisation or recyling initiatives, which offer partial solutions, there will always be large quantities of waste which must be disposed of, and for these landfill offers the most readily available option. Even after incineration or treatment the residues must go to landfill. There is nowhere else for them to go.

We should also recognise from the outset that properly conducted landfill offers a considerable benefit to the community as a restoration technique for land.

That said, the particular role of landfill disposal with respect to hazardous wastes will, I believe, be limited unless a much more considered approach to the design, conduct and monitoring of the process is adopted than has been routinely applied in the past.

Government policy

This is quite clear: the continuation of landfill disposal for a wide range of wastes, including hazardous wastes, represents a firm policy commitment by Government.

The Department of the Environment has researched the environmental implications of landfill disposal. The main conclusion of the DOE co-operative programme of research on the behaviour of hazardous wastes in landfill sites (1) was that "sensible landfill is realistic and an ultra-cautious approach to landfill of hazardous and other types of waste is unjustified." That conclusion was published in 1976, and has been strongly defended by successive governments ever since. Critics of this policy stance have been mainly concerned to challenge, not the conclusion itself, but rather to express doubts about how "sensible" some landfills are (see, for example, HWI 1st report 1985) (2).

In its most recent policy statement on waste management - the response (3) to the Second report of the Environment Committee (4) - the Government has reiterated its conviction

that the UK is following the correct course, and contrasts the UK's experience with that of many other countries.

About 90% of household and commercial waste is landfilled in the UK, generally speaking at quite separate facilities from those handling industrial wastes. However, certain industrial wastes, many of which have been treated, are disposed of in landfills taking household and similar waste. This is known as co-disposal and the technique relies on exploiting natural biological and chemical processes occurring within the body of the waste mass to change the chemical nature of both the industrial and the household waste so that the material becomes environmentally benign. I have emphasised this because it means that all co-disposal sites are by definition environmentally safe and those which cause pollution are, therefore, not co-disposal. The same definition occurs in the Department's 1989 revision of Waste Management Paper No. 4 (5).

Government considers that co-disposal is particularly well-suited to the geology of certain parts of the UK, that the process has been well researched since 1974 and that this research supports the view that carefully engineered and controlled landfill is a safe long term disposal method for a wide range of wastes. It claims that experience of both mono- and co-disposal in the UK has been good, observing that there have been few major pollution incidents involving landfills, and that landfilling technology continues to be monitored and researched through the Department of the Environment's research programme.

In other countries experience with landfill has in many cases been quite different. Indiscriminate dumping of industrial waste without proper controls has often led to large scale pollution and consequent large scale public expenditure to achieve satisfactory clean up. Public opinion has been outraged by such incidents, but in demanding higher standards it has turned not only against uncontrolled dumping but also against properly engineered landfill and even incineration and treatment. We have avoided such intemperate outbursts of public opinion in the UK, although objections to all aspects of waste disposal are increasingly well orchestrated, and will continue to feature more and more in the public debate surrounding specific local waste management proposals.

The Government is quite clear in its view. It sees no reason to change the UK's landfill methods, which are well researched and have not resulted in the disasters that have occurred elsewhere. In particular it sees no reason to abandon co-disposal landfill in favour of entombment landfill, which is a method increasingly adopted in other countries as a reaction to their pollution problems. Entombment landfill is no more than long term storage. The wastes do not biodegrade or chemically change. They sit in their concrete case for future generations to deal with.

Thus Government policy with respect to waste disposal by landfill is quite unequivocal: it is far better to deal with our waste now through our well researched and monitored processes than to change to methods which even their advocates acknowledge merely postpone real disposal to some future date.

Significant milestones in the development of current landfill technology

The disposal of wastes to land is as old as mankind; in the UK its conduct has been subject to guidance by Government for some 60 years, when the concept of controlled tipping practice was introduced in the form of recommendations by the Ministry of Health. The responsibility for this practice was later transferred to the Ministry of Housing and Local Government (6) which became part of the newly created Department of the Environment in 1971.

Taking as my starting point 1966/67, i.e. before the 1974 Local Governmemt reorganisation and before the Control of Pollution Act 1974 (the COPA), it is notable that in that year there were 1,174 refuse disposal authorities in England, employing 1,737 disposal sites for the disposal of 19.5 million tonnes of household, trade, commercial, industrial and construction industry wastes (7). The tonneage figures must be caveated since most were based on estimated weights. These statistics should be compared with data 20 years on. In 1986/87 there were 71 waste disposal authorities in England employing, directly or indirectly, some 800 disposal sites for the disposal of 23 million tonnes of household, trade, commercial, industrial and construction industry wastes. (Such has been the rate of progress that exactly the same caveats apply to the tonneage.)

We know that the concept of controlled tipping was far from universally applied as the Department of the Environment's Report <u>Refuse Disposal</u> (1971) acknowledged - "from our observations and also from our experience, we are satisfied that there has been a failure in many instances to observe fully the tipping precautions. This view is supported by the returns from local authorities which indicated that out of a total of 14 million tonnes of house and trade refuse tipped direct, over 25 per cent waste was tipped in a semi-controlled or uncontrolled way", and "we found that failure to observe fully the tipping precautions recommended by the former Ministry of Housing and Local Government had in many instances resulted in difficulties and complaints. Often this failure arose from an unwillingness to spend sufficient money on the system to achieve a good standard".

Thus only 20 years ago waste disposal was achieved via a vast number of small tips, many of which were conducted according to only the most rudimentary of controls (the total of local authority sites above takes no account of those operated by the private sector, and the report of the

Key Committee (8) in 1970 observed that of some 11 million tons of industrial solid and semi-solid wastes identified in its survey about 90 per cent was disposed of by tipping, and that less than 10 per cent of the total went to local authority tips).

If the first milestone was the attempt to impose some discipline on landfill operations by the introduction of recommended tipping procedures about 60 years ago, the second and rather more significant was the dual influence of the 1972 Local Government Act and the 1974 Control of Pollution Act which together created the current framework for modern waste disposal. The smaller number of larger waste disposal authorities (46 as created in England) were better equipped to rationalise and improve the public sector landfill situation and to impose the disposal site licensing controls introduced by the COPA. Thus the slow process towards improving landfill technology was put in motion.

Thereafter, progress to the 1990s was punctuated by a number of significant events in waste management, of which I have highlighted only those which seem to be of particular importance in defining the future of the landfill disposal industry. To attempt to enumerate all the significant events would encompass a seemingly endless list of reports of Select Committees, Royal Commissions, Government responses, parliamentary debates, waste management papers, consultation papers on proposed legislation, etc. The last 20 years have featured an increasingly high public profile for the waste management industry. My attempt at flagging those events of fundamental importance reads as follows::

a. the Deposit of Poisonous Waste Act 1972; the first specific waste management legislation in the UK, which began to focus attention on the standards to which we operated and highlighted the information needs of the regulators;

b. the Control of Pollution Act 1974 and its subordinate regulations (already mentioned);

c. the Department of the Environment's continuing programme of landfill research following the publication, in 1976, of the "Brown Book";

d. the publication in 1976 of Waste Management Paper No. 4 on disposal site licensing and its revision in 1988;

e. the EC Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous subjects (the Groundwater Directive);

f. the publication in 1986 of Waste Management Paper No. 26, on landfilling wastes (9);

g. the publication in 1989 of Waste Management Paper No. 27 on landfill gas (10).

In terms of the future conduct of landfill, there can be no doubt that the last three entries above will have the most profound impact - and current landfill designs, which are for the future generation of operational sites - are already based on their requirements. All point to the same principal conclusion, that in the future, landfill sites, except for those intended to accept a very limited range of waste types, will be designed, engineered and operated on the containment principle.

The infiltration of rainfall and surface water, together with the deliberate introduction of liquid wastes into a landfill acts with the decomposition of wastes to produce a leachate of high organic and inorganic content, and high in suspended solids. Whilst it has been demonstrated that the leachate from household waste landfills does not differ markedly from that from co-disposal sites which have received, in addition, hazardous industrial wastes, the potential for the presence in the latter of high concentrations of heavy metals could require more stringent containment requirements. If such leachates enter ground or surface waters before sufficient attenuation has occurred, then pollution will result.

The Groundwater Directive denies the discretion to permit waste disposal activities to impact on the quality of aquifers, even those whith no planned utilisation. Under Part II of the Control of Pollution Act 1974, it is an offence to knowingly permit poisonous, noxious or polluting matter to enter ground or surface waters. The implementation of these requirements in future aquifer protection policies will influence a trend towards:

a. the severe limitation of the types of waste acceptable at disperse and attenuate sites; and,

b. the limitation by waste regulation authorities of licensing of sites for potentially polluting wastes to containment only.

Waste Management Paper No. 27 requires that landfill gas should not be permitted to escape from a landfill site in an uncontrolled manner. Since the evolution of landfill gas is an inevitable consequence of microbial activity upon biodegradable materials deposited in landfill sites, this provides further clear indication that engineered containment is now as essential aspect for disposal sites receiving such materials.

Already the waste disposal industry has, in its modern landfill designs, progressed a long way from the shabby and neglected tips of yesteryear. We can look forward to a continuing evolution as the last of the previous generation of tips gradually close.

Landfill site selection is no longer the ad hoc procedure that has resulted in some inappropriate locations in the

past. Potential sites are selected on the basis of environmental impact. Should a preferred location arise from such a screening exercise, a detailed site investigation is undertaken to characterise the site for its suitability for waste disposal in terms of its geotechnical and hydrogeological properties. This investigation provides additional information regarding the preparative engineering necessary further to safeguard the site environment.

For certain classes of landfill sites, i.e. those designed to accept 75,000 tonnes per annum of waste or more, or for those designed to accept special wastes, an environmental statement is now a formal requirement at the stage of application for planning permission, under the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988.

Landfill site licensing under the Control of Pollution Act 1974 has served well in moderating many of the historical poor practices which have bedevilled landfill disposal, and has resulted in considerably improved standards. However, the Hazardous Waste Inspectorate (now part of HMIP) was forced to conclude in its three Reports:

a. that considerable variation existed in the standards required of waste disposal operators by different waste disposal authorities; and,

b. that the effectiveness of many site licences in terms of their primary function of ensuring environmental protection was questionable.

As a consequence, the Government has introduced revised site licensing guidelines with its 1988 revision of the 1976 Waste Management Paper No. 4, The Licensing of Waste Disposal Facilities. This provides clear guidance on the regulation of the day-to-day operation of waste disposal facilities and puts particular emphasis on the key role of a comprehensive working plan. To ensure the uniform application of the higher standards necessary, it is anticipated that the Control of Pollution (Amendment) Bill will contain provisions for HMIP to undertake a formal auditing role over the way in which waste regulatory authorities discharge their duties with respect to waste management, and to create statutory Codes of Practice based upon the existing and advisory Waste Management Papers.

Landfill design, the preparation of working plans, landfill site regulation and monitoring are today the province of multidisciplinary teams, better equipped to identify and solve the diverse technical issues involved. whilst many regulatory authorities have been criticised in the recent past for the apparently low priority accorded to their waste regulatory duties, the current trend is clear. A large scale recruitment programme is underway for site licensing and inspection staff, as evidence of which, at the time of writing some 140 new staff in these important areas have

attended site licensing training courses organised by the Institute of Wastes Management.

The level of knowledge of waste management personnel engaged at landfill disposal sites is increasing. The Institute of Wastes Management and the National Association of Waste Disposal Contractors are concerned to improve the professionalism of all concerned within the industry. We now have a Wastes Management Industry Training Board. Proposals for a structured education and training scheme with qualifications recognised throughout the industry are under development.

We are moving toward an era when landfill disposal sites will be subjected to the closest possible scrutiny at the planning stage, to ensure that potential environmental impact is considered; at the licensing stage, to ensure that full regard has been taken, in their design and proposed operation, of the preparative engineering, operational requirements and monitoring needs to afford appropriate protection of the environment. Staff are receiving training in the necessary disciplines to ensure that the operational controls imposed can be rigorously implemented. Appropriate monitoring frequencies have been defined; and a modern landfill will incorporate a sophisticated monitoring array by which the quality of groundwater, surface water, the level, rate of build up and quality of leachate can be evaluated and by which landfill gas can be monitored. Multifunctional leachate protection measures will have been incorporated in the design including, where appropriate, leachate collection, extraction and treatment systems. Similarly, landfill gas collection (and gas condensate) collection and removal systems are commonplace.

As a final, and essential, part of the modern concept of landfill operation, the Control of Pollution (Amendment) Bill is likely to introduce, for the first time, the ability to incorporate restoration and aftercare conditions in a site licence, affording the certainty that the continued potential impact of a landfill site on the environment can be monitored and remedial actions, if necessary, can be enforced, for an appropriate period after closure.

Today's landfill designs and operations are already far removed from yesterday's bad practices. Landfills are sited, designed, constructed and operated to high technical and regulatory standards. These standards will be more uniformly achieved in the future. As the necessary improvements are implemented, landfill will inevitably move away from its historically perceived position as a low cost option - Lord Gregson's "cheapest tolerable means". Whilst this may itself result in a reassessment of the best practicable environmental option for the disposal of certain waste streams, there can be no doubt that landfill will continue to play a predominant role in waste disposal. Waste minimisation and clean technologies will certainly influence the quantities and types of waste coming forward

for ultimate disposal, but we can confidently predict that landfill will continue to be the essential foundation stone on which the nation's waste management strategy is founded.

Perhaps particularly with respect to co-disposal landfill, other influences will modify our current approach. For example, the proportion of hazardous wastes seeking landfill disposal will undoubtedly be modified as the proposed HMIP controls impact on processes scheduled for their total polluting load, rather than simply in terms of air pollution potential. We could reasonably predict more in-house treatment of chemical wastes as a direct consequence, producing a higher proportion of more environment friendly wastes from industry. The impending restrictions on the marine disposal of industrial liquid wastes and sewage sludge implies an additional burden on landfill, as in-house treatment results in, perhaps, considerably increased tonneages of filter cakes. In general as the containment philosophy bites harder, co-disposal of liquid wastes will have to be more carefully engineered in order to minimise leachate production. The historical practice of batch loading the refuse biomass with concentrations of industrial hazardous wastes, with its potential for localised sterilisation of the microbial population, or for interactions with previously co-disposed wastes is unlikely to represent the optimum way forward. Care of the refuse biomass, the heart of the beneficial physical, chemical and biological processes that a well ordered landfill disposal operation can provide, implies much greater care in supplying a consistent feedstock. This then indicates much more reliance in the future on pretreatment, whether in-house, at waste treatment centres, or - and we have already seen a planning application for one such (11) - at the co-disposal landfill site itself. Pretreatment will enable the control of acidity and alkalinity, the precipitation of soluble heavy metals and the removal of solids for incorporation in the landfill in insoluble form. Liquids will be pumped for sub-surface injection directly into the biomass, rendering the present system of trenching into predeposited refuse redundant. This scenario can be extended to perhaps represent the ultimate harnessing of the co-disposal system to provide for close monitoring of all wastes received, the controlled production of a more benign diet for the biomass, and close monitoring of the functioning of the decomposition process. Leachate levels will be closely monitored and leachate treatment plant provided for all liquids leaving the site.

I have referred to the improvements in landfill technology that have been achieved since site licensing was introduced in 1976, and to the way in which the system has fallen short of the Government's objectives of providing uniformly high standards of disposal site operation and environmental protection. I have predicted the uniform attainment of much higher standards in the future, on the basis of more rigorous enforcement of existing controls, better advice from Government and amendments to the Control of Pollution

Act 1974. The principal driving force, however, on which I base my view forward, is the impending imposition, via the Control of Pollution (Amendment) Bill, of a statutory duty of care on waste producers. Once in place, this requirement will mean that all producers of controlled waste must exercise discrimination in their choice of waste disposal contractor, and no longer select the ultimate destination of their waste streams on the basis of the lowest cost option.

References

1. Co-operative programme of research on the behaviour of hazardous wastes in landfill sites. Department of the Environment (1978). Final report of the Policy Review Committee. ISBN 0 11 7512575

2. The Hazardous Waste Inspectorate First Report: 'Hazardous Waste Management, an overview'. Department of the Environment (1985)

3. The Government's reply to the second report from the Environment Committee. 'Toxic Waste' Cmnd. 679. HMSO (1989) ISBN 0 10 106792 5

4. House of Commons Environment Committee: 'Toxic Waste' HMSO (1989) ISBN 0 01 279589 4

5. Her Majesty's Inspectorate of Pollution 'Waste Management paper No. 4: 'The licensing of waste facilities'. HMSO (1988) ISBN 0 11 752157 4

6. See Appendix C: Department of the Environment: 'Refuse Disposal' HMSO (1971) ISBN 11 750348 7

7. Department of the Environmment; 'Refuse Disposal' HMSO (1971) SBN 11 750348 7

8. Ministry of Housing and Local Government: 'Disposal of Solid Toxic Wastes' HMSO (1970) SBN 11 750278 2

9. Department of the Environment: Waste Management Paper No. 26: Landfilling wastes' HMSO (1986) ISBN 0 11 751891 3

10. Her Majesty's Inspectorate of Pollution. Waste Management Paper No. 27: 'The control of landfill gas' HMSO (1989) ISBN 0 11 752175 2

11. Private communication from Mr Barry Hurley, Cleanaway, subject to a planning application to Basildon District Council by Cleanaway Ltd., 5 July 1989

THE FUTURE OF INCINERATION IN THE UK

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In discussing the future of municipal solid waste incineration it is necessary firstly to examine trends in incineration capacity and secondly to explore the characteristics of the plant involved. The overall capacity will be a summation of the capacity of existing sites together with any new plant on new sites. The characteristics of existing plants may well be different from the next generation of waste burners.

It is commonly argued that future capacity trends will simply depend on the price people are prepared to pay to get rid of their waste but this is a gross simplification. This 'price' will depend on a great number of contributory factors, both financial and environmental. The relative importance and nature of these factors will vary depending upon whether we are considering existing or new plant capacity. This paper will first look at existing capacity and then touch on future prospects. It will endeavour to discuss the nature of the variability of the contributory factors and, on the basis of best available estimates, predict future capacity trends.

Existing Plant Capacity

The UK currently incinerates ca. 3 MT/a refuse - 8% of the total waste arisings. The fact that there is any existing capacity at all indicates that the waste arisings are sufficient and suitable to support large incinerator plant. Similarly these existing plant are, at the very least, functional. Finally it indicates that, in some areas, landfill of untreated waste is not the preferred option. Whether or not existing capacity is maintained will depend on whether these postulates remain valid during the next decade.

Over the past few decades UK refuse arisings per capita have been increasing and have shown little sign of decreasing in line with population trends. They are also considerably lower than in some other developed countries, particularly North America and the Pacific OECD countries. Thus, it seems likely that the amount of refuse available for incineration will maintain its current level or rise slightly in the near future - though the UK data currently

available is not complete enough to determine the magnitude of the trend with confidence. There are, however, a number of changes which might, in the future, affect both mass and composition. There are indications that there is a trend towards a greater proportion of paper and putrescibles in waste. This is due to the increased use of packaging and free newspapers, to some extent counteracted by a greater collection of garden type waste. The introduction of wheeled bins in some areas has resulted in an average increase per household of 25 - 30% with an associated rise in paper and garden waste content. Nevertheless there is no marked trend for a shift in the calorific value of domestic refuse of the currently encountered range.

Whether or not plants continue to be deemed 'functional' will depend on their mechanical soundness and on whether the general public find their performance acceptable. Nearly all the UK plant are old, most having been built in the early seventies. However 'incinerators' are more than just furnaces, consisting as they do of sites with associated services, building and operating licences as well as the combustion equipment. With adequate maintenance and moderate investment plant could be kept running indefinitely; major modifications, even furnace rebuilding, would be considerably cheaper than building a new incinerator from scratch. As signatories to the new European Directives on incineration all our plants will now require considerable investment in furnace technology, pollution control equipment, instrumentation and staff training to enable them to operate in an environmentally acceptable manner. For many of the smaller and older plants these costs, which could range between £0.75M - £1.5M/10 tonne unit, will be unacceptably high and as many as 20 may close. However there will be some rebuilding on existing sites at a later date.

Alternatives to incineration are of course available though in the near future landfill will continue to be far and away the predominant disposal option. Indeed ultimately it is the only final option, even incinerator residues will need to be disposed of that way. The economics of landfill management are not yet fully characterised but it is commonly agreed that tipping fees, in many cases, do not reflect the full cost of the care of sites throughout their working lifetime or aftercare when tipping has ceased.

Thus under these circumstances some operators faced with hefty investment programmes to keep incinerators going will switch to landfill where it is still available. However for some authorities this will still not be possible or, because their plants are equipped to sell energy, will wish to continue operation. Together these plants may account for a significant proportion of the total existing UK capacity.

Plant operators have until December 1996, before the EC Air Emissions Directives come into force. Many are currently in the process of evaluating options and on the basis of

discussions with a substantial proportion of them WSL has come up with the capacity trend shown in Figure 1.

Recent R&D work on existing plant has indicated that there is considerable scope for upgrading the performance of existing plant and this, together with reopened sites, is the justification for the upturn in the 'existing capacity' in the future.

New Plant Capacity on New Sites

Two of the major factors affecting the growth at which plant accumulate have already been touched on, namely: whether an adequate supply of suitable waste will be available and whether the public will tolerate new plant where there were none before. Many of the points made earlier still apply over the longer term horizon now considered i.e. 20 - 30 years.

It is likely that there will be a greater move to integrated waste management and recycling options will become more viable, especially as the resource potential of commercial waste is recognised. Nevertheless we will, more than ever, require robust disposal routes and those least subject to fickle economic factors will continue to be landfill and incineration. It is likely that waste regulatory authorities will have to base much of their strategic planning around these two options. So even with more recycling activity it seems unlikely that there will be either a shortage of refuse or that it will become unburnable.

In some countries there has been intense public concern over the environmental aspects of incineration, particularly air pollution emission issues. Hard lobbying by European countries determined to exploit incineration has led to the development of stringent emission control regimes for both existing and proposed incinerators. This legislation is designed to allay public concerns and permit, not prohibit, the use of properly controlled incineration; and this to a large extent has happened in many countries - the USA, Germany and Sweden to name but a few. The UK environmental consciousness follows rather than leads on this issue and there is little reason to suspect that, in the future, UK public concern would run counter to that of the citizens of other EC countries. In fact it is pertinent to ask whether any UK plants have ever been shut down purely for domestic environmental reasons. It was surprising how little public reaction there was to the recent DoE report on dioxins in the environment. However that is not to say that requests to build new incineration plants won't result in a harder fought and more searching examination of options than we are currently used to, as is the case in the countries mentioned above.

While the public debate over the hazards of incineration is well developed the problems associated with the

alternatives, particularly landfill, are only just emerging. It is arguable that current legislation is inequitable. Incineration is now properly regulated but is landfill? Landfill gas emissions exacerbate a number of larger air pollution problems and uncontrolled leachate is an acknowledged water pollution problem. There is no shortage of evidence that the UK will soon be coming under increasing international pressure to regulate landfill management more tightly, indeed the DoE have gone a good way to anticipating it. The current waste debate will not only have the effect of educating the public on waste issues generally but will inevitably lead to higher tipping fees. In short it is likely that an automatic preference for landfill will become less likely. Consequently public concerns are more likely to delay rather than prevent an increased use of incineration.

The more problematic question is 'What is the likely rate of accumulation of new capacity and when will it begin to come on line?' There is already a steady increase in capacity in Germany, the USA and Japan, all countries incidentally with an acute awareness of environmental issues. But the factors likely to affect developments in the UK are:

a. Energy Policy. To date it has been difficult to sell electricity generated from waste incineration at a price likely to encourage investment in waste burning power plants. The privatisation of the electricity industry and the inclusion of a non fossil fuel tariff will, to some extent, open new opportunities. The potential economic and environmental advantages of district heating are also increasing. Future developments might also allow marginal generators to reduce costs by co-firing wastes such as coal mining spoil for example.

b. Landfill Availability. It appears likely that there will be increasing competition for landfill in the next 2 - 3 decades viz. the shortfall anticipated by the South Eastern Region for example (SERPLAN 2000). Also it is likely that there will be competition for void space from inert materials such as building rubble etc. which will require none of the costly after care required for domestic refuse. Similarly there will be increased waste streams from other processes which may well also compete, products of flue gas desulphurisation and sewage sludge for example. Indeed owners of landfill capacity are becoming increasingly aware of the value of this capital asset and may well see waste processing such as incineration as a means of protecting and enhancing its value.

c. Resources Human/Financial. The new generation of plants will be larger and more difficult to operate than we are used to, incorporating acid gas control

systems etc. In 1980 13% of refuse incineration capacity was equipped with heat recovery systems; we can expect all new plant to be so equipped. They will have to be tightly managed to ensure that energy recovery is maximised, that complex pollution control criteria are met and that, in general, costs are kept to a minimum. These are not inconsiderable requirements and may well be beyond the scope of many public sector operators. Similarly it is unlikely that the necessary investment capital can be found in the public sector alone.

These factors combined indicate that any new capacity would be based on highly sophisticated and large scale technology capable of providing an income to offset costs. It would have a signficant private sector component either in terms of investment and/or management. Thus as well as new mass burn facilities it is likely that we will see an increase in co-firing 'flock' RDF in power stations and cement kilns; co-firing of special wastes such as sewage sludge and hospital wastes could also be used to offset the costs.

Bearing in mind the early stage of development we are at in many of the factors identified above, it is perhaps unwise to try to project capacity growth too far into the future. However, there are some indicators which might be used to attempt to make a projection to stimulate debate in the area. The percentage of refuse incinerated in the UK (8%) is lower than in most other countries (Table 1) but there are currently plans for new plant - the South London and Isle of Man plants to name but two. There is, perhaps, a capacity below which incineration will be uneconomic - since most new plants will generate power - German figures suggest this is ca. 170 kT/a. It may also be possible to anticipate a growth rate by looking overseas for analogues. Running through this exercise and assuming plant capacity starts to build in 1994, when the South London plant may come on line, assuming 170,000 tonnes per year/unit and a growth rate of 85,000 tonnes per year, i.e. a plant every two years would give the situation shown in Figure 1. This growth rate compares with that in the USA of 1-2% p.a. and Germany of 5% p.a. Even on this modest projection the total capacity in 2010 will surpass that in 1980.

While one can anticipate a growth in incineration capacity the environmental burden and particularly the dioxin emissions should fall. It is estimated that dioxin emissions from incinerators may have been as high as 1.5Kg in 1980 but on the basis of figures postulated in Fig. 1 should be less than 150g in 2010 because of the adoption of modern pollution abatement technology. A further point of interest is that the nature of pollution will change since increasingly waste burning will be incorporated with other processes and hence the character of the emission will be new and possibly different from that encountered to date.

Conclusion

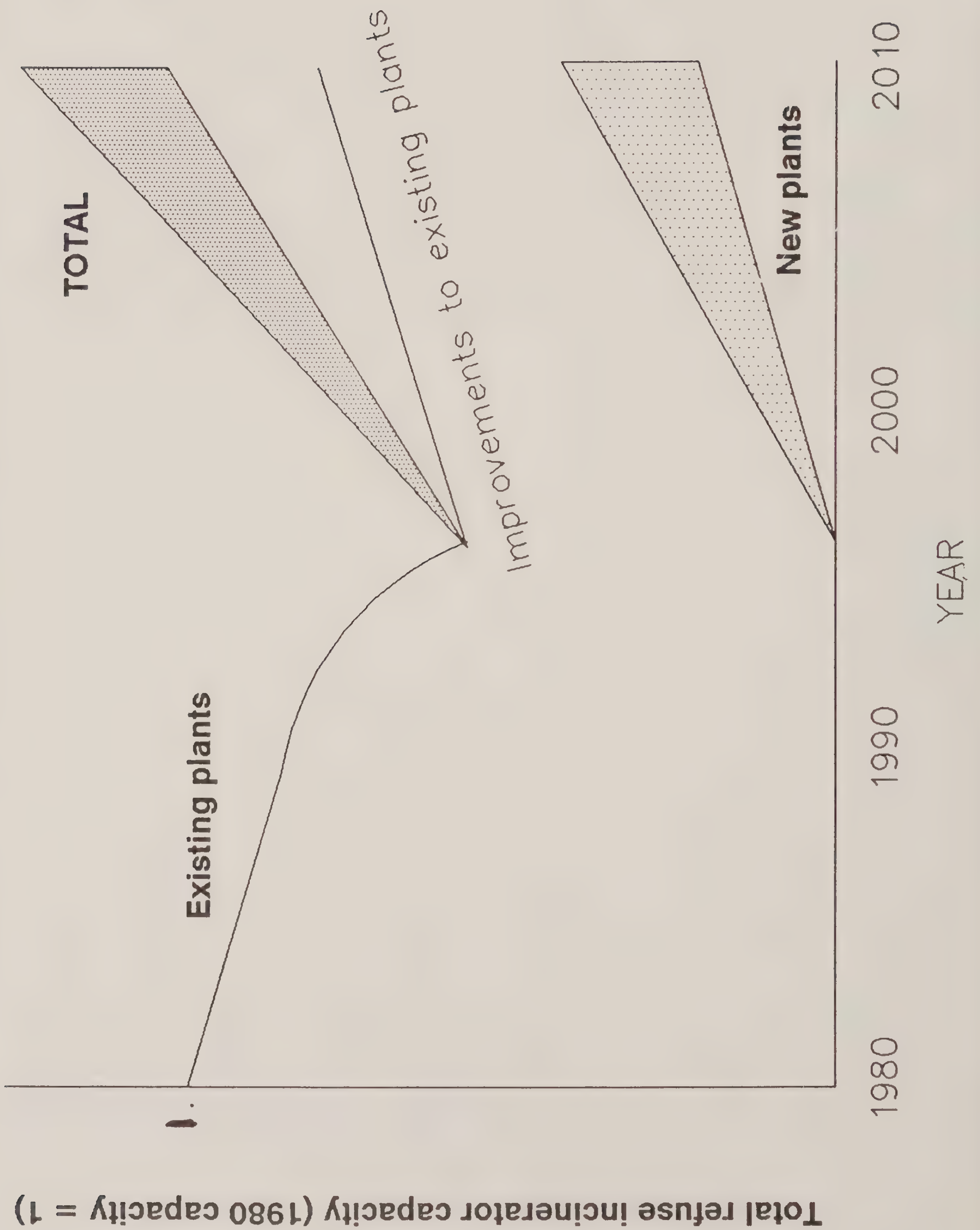
When considering the future of municipal solid waste burning in the UK the following picture emerges. In the near future the existing population of ageing and largely out of date plant will decrease. There are, on the whole, landfill options which are easier to utilise than upgrading existing plant. Nevertheless there are strong indications that conditions will become more conducive to the growth of a new generation of plant able to exploit the energy potential of the wastes. The new plants, and those remaining older plant, will be highly sophisticated and will require careful management. This will place increasing demands on traditional operating bodies and it is likely to lead to an increase in private sector involvement both in the financing and operation of plant. It is possible that following the nett decline in capacity in the next 5 - 10 years there will be a strong growth in capacity which could exceed the 1980 capacity figure by the year 2010.

TABLE 1

Percent incineration in various countries

	Percentage of waste arisings incinerated
Switzerland	80%
Japan	68%
Singapore	60%
Sweden	50%
Netherlands	40%
France	36%
West Germany	35%
Austria	18%
USA	10%
UK	8%

Figure 1: Projected UK incinerator capacity



THE POTENTIAL FOR RECYCLING

By

Mike Flood
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Introduction

Modern society is manifestly wasteful. Materials worth hundreds of millions of pounds are simply thrown away each year, often to the detriment of the environment. And people are beginning to object. To the person in the street, the solution is obvious:

- discourage wasteful habits;
- use less material, especially packaging;
- design containers for reuse; and
- recover materials from waste and recycle them.

Unfortunately, things are not that simple.

Indeed, the concepts underlying the recycling debate are complex. Pursued to their obvious conclusion, they raise profound questions about the worth that we place in different activities. The debate over packaging, for example, boils down to whether the particular service that is being provided, whether it is protecting goods in transit, dispensing food, or deterring theft from stores can justify the materials and energy that are consumed, and the environmental damage that is caused. The service may be for the benefit of the manufacturer, the store keeper, or the customer, or all three.

Moreover, what raw data that is available, whether it concerns the economics of reclamation or the practicality of individual recycling schemes, is often difficult to interpret because of the assumptions used, or the local conditions that apply.

One frequently finds people arguing that some scheme or other works perfectly satisfactorily abroad, perhaps in Sweden or the United States, and that it can equally well work here. But overseas experience is not always relevant because people have different attitudes and behaviour patterns, and the political context may not be the same. There may also be a hidden agenda (eg the use of deposit legislation to protect the interests of a domestic beverage industry -- see section 3.4).

Add to this the fact that the field of materials and energy reclamation is dominated by powerful vested interests in the shape of primary producers, the packaging lobby, the soft drinks industry, the waste disposal and reclamation industries, local authorities and voluntary groups, and you have a recipe for fierce controversy.

Some emphasise the opportunities and the environmental benefits that are afforded by reclamation, others are concerned about the difficulties of implementing practical and economically viable schemes. Some envisage a complete reorganisation of society, and major changes in lifestyle; others look at what is possible within the existing infrastructure, or something similar.

Scope of the Paper

The title of my paper is 'The Potential for Recycling'. This is a difficult subject to do justice to in such a short paper. It covers so many issues. Following the dictum I once saw on a calendar: 'Eat your elephant one bite at a time', I intend to tackle this subject in small bite-sized chunks. If you find that in doing so I have over-simplifed the issues, I should welcome your comments.

I make no claim for great originality in this paper. I have relied on the work of many people far more expert than myself in the field of recycling. I have acknowledged some of the key papers at the end.

I want to limit my remarks to the reclamation of materials and energy from post-consumer domestic waste, rather than from commercial and industrial waste (which, by comparison, can be more straight forward, especially with pre-consumer wastes). Household waste accounts for roughly two thirds of municipal solid waste (MSW); 80% is collected directly, and the rest comes from civic amenity sites. I want to explore a number of contentious issues, particularly packaging. Around 90% of the glass, metal and plastic in MSW comes from packaging, and 20% of the paper.

There are no accurate recent data of the breakdown of waste, other than by broad category (paper, glass, etc.). The figures given in Figure 1 are from 1980. Packaging today probably accounts for 25-30% by weight, and 50% by volume. The main components of MSW are paper and card (33%), putrescible organic waste (20%); metals (8%); glass (9%); and plastics (6%). There are also textiles, miscellaneous items, and fines. Moisture accounts for a third by weight.

I should like to begin by briefly reminding you of why recycling is important.

1 WHY RECYCLE?

1.1 Why Recycling Makes Sense

The arguments in favour of recovering materials and or energy from waste can be summarised as follows:

o Recycling makes much better use of resources, which in turn reduces the environmental damage and pollution associated with mining, processing and fabrication of fresh raw materials -- and the provisions of energy to carry out these processes.

o In the case of paper, recycling reduces the need for conifer plantations and pulp factories, with all the environmental problems that these cause.

o Recycling reduces overall waste disposal costs and the need for landfill. It may deter anti-social practices, such as pouring sump oil down the drain, or littering.

o Recycling can save energy -- although not invariably.

o Recycling provides local employment, reduces imports and improves the balance of trade.

o Recycling creates greater social awareness, especially in children, and is popular with the public who dislike throwing things away that could in principle be recycled or reused.

With recycling, ordinary people can feel that they are actually doing something to help reduce pollution and waste -- although I've also heard it suggested that supporting recycling schemes is one way people can salve their consciences for their high levels of consumption! Nevertheless, many successful schemes are operating in Europe and North America.

The arguments for recycling are appealing. Unfortunately, they do not tell the whole story, as anyone involved in the business will know. The arguments need to be set in proper context, which is what I have attempted to do in the rest of my paper.

Some Definitions

Primary Raw Materials are derived from natural resources, and include ores (metals), trees (paper, rubber) and fossil fuels (plastics).

Reclamation is the collection, sorting, processing and upgrading of a product or material to convert it into a form suitable for recycling.

Recycling is the process of reclaiming materials that would otherwise by thrown away, and refining and reprocessing them

so as to produce potentially useful products.

Reusable or Refillable containers are ones that are designed to be returned, cleaned and refilled.

Secondary Raw Materials are materials that have been reclaimed, and include metals, glass, paper and plastics.

1.2 The Options for Materials Reclamation and Energy Recovery

Separation from Mixed Wastes

It was common practice, around the turn of the century, to sort municipal waste by hand and salvage paper and card, textiles, metals, glass and even bones (which were boiled down and turned into glue). The work must have been extremely unpleasant. By the 1940s the practice had been largely abandoned.

Interest in the mechanical sorting of refuse developed in the 1970s as a result of a government initiative. Most of the work concentrated on producing fuel from waste, although an experimental plant at Doncaster did investigate recovery of ferrous metal, glass and paper, as well as waste derived fuel. The plant worked of a fashion, but was not economic and did not operate for long.

The general consensus today is that mechanical separation is too difficult and too expensive -- although this does not rule out, for example, the recovery of ferrous metals and certain other materials at transfer stations, incinerator plant, and during the manufacture of waste derived fuel.

Separation at Source

There are several types of separation at source scheme. These include:

o collect schemes where households voluntarily put different categories of waste into two or more separate bins or plastic bags for kerb-side collection;

o deposit schemes where households are asked to return certain items such as newspapers, aluminium cans and glass bottles to unmanned recycling centres (bottle banks, paper igloos, skips for cans); and possibly, reverse vending machines; some also take used engine oil, textiles, and plastics; and
o civic amenity sites, which take bulky items as well as mixed waste, and where some degree of separation usually takes place. The sites are generally supervised.

Considerable experience has been gained with all these systems in Europe and North America, although not all of it is encouraging.

Energy from Waste

Three of the principal ways of obtaining energy from MSW are via landfill gas, mass burn incineration, and the manufacture of waste derived fuel (WDF).

Landfill gas: The generation of gas from landfill sites is already big business. Twenty schemes have been installed in the UK in recent years, and if operators can be guaranteed a fair price for electricity (say 3 p/kWh), many more can be expected. The technique involves drawing gas from capped 'cells' of waste using a network of wells and connecting pipes. Roughly half of the gas is used for direct heat in industry; the rest, for electricity generation.

Incineration: Mass burn incineration has been used for years to dispose of insanitary material. Indeed, the technology was pioneered in Britain towards the end of the last century. Incinerators today are considerably larger and more efficient, than the early batch fed 'destructor' units. They are designed for continuous operation, and burn waste as it comes, straight off the collection trucks. Over 600 schemes now operate in Europe and North America; 40% are equipped with boilers to supply heat for electricity generation, or for district heating or industrial use. Some provide both heat and power. A typical unit would handle the waste from a town of half a million people (around 250,000 tonnes of waste per year) and produce 15-20 MW of electricity and or 50-100 MW of heat. There are only a handful in the UK, including Edmonton power station, which takes a tenth of London's refuse.

Waste Derived Fuel: Production of waste derived fuel, or WDF, involves separating out paper and plastic film from the other components of the waste. This combustible fraction is then shredded to produce a light flock fuel, which can either be burnt directly in conventional solid-fuel boilers, or alternatively compressed into hard fuel pellets, which can substitute for coal in a number of industrial applications. A plant handling say 85,000 tonnes of MSW per year might produce 20,000 tonnes of WDF, capable of generating around 6 MW. Half a dozen WDF plants have been built in the UK They have operated with varying degree of success.

These options are compared in section 3.7.

2 WHO'S INTERESTED IN RECYCLING?

It is unfortunate that the debate on materials recovery so often seems to focus on the problem of collection rather than looking at all of the stages in the recycling process (storage, transport, cleaning, conversion, marketing, etc.)

Some very powerful groups have a direct interest, and it is vital to understand the way they would be affected by a switch to greater recycling, because without their active

support and participation the full potential for recycling will never be achieved. For some, like the primary producers and the packaging industry, materials reclamation could threaten business, or involve massive capital investment (to retool or reorganise to handle more secondary material). For others, it may be seen as an opportunity to make money and or save resources and energy.

I have discussed below the groups likely to be most affected by significant changes in waste management practice.

2.1 Primary Manufacturers

Primary manufacturers includes those that supply and process the raw materials used, for example, in packaging -- the metal ores (aluminium and iron), and other minerals (silica and limestone for glass, and clay for paper-making), oil and gas (for plastics), and wood pulp (for paper).

2.2 The Packaging Industry

The packaging industry has a turnover of around £4,000 million per annum (see Figure 2). It includes those that manufacture packaging materials (tinplate and aluminium foil, glass, plastic, paper and board), and convert these materials into products (such as bottles, cans and boxes) which supply the market. It can also be taken to include: those that supply and install machinery for applying the packaging (bottling plant, vacuum pack lines, and the like); those that are involved with the storage, transport and distribution of packaged material; and even those that supply the fuel and power which keeps the whole operation going.

2.3 The Soft Drinks Industry

Two major manufacturers dominate the British soft drinks industry1 (Britvic and Coca-Cola-Schweppes), and there are over 140 small companies. The total workforce is estimated at around 23,000 people. The industry has an annual turnover of around £3 billion. (Annual consumption of soft drinks per head of population is about 108 litres.)

2.4 The Recycling Industry

Several million tonnes of waste paper and ferrous metals are reclaimed each year in the UK, together with several hundred thousand tonnes of non-ferrous metals (like lead, copper and aluminium), glass, plastic, textiles, chemicals and used oil (see Figure 3). However, very little of this material comes from domestic post consumer waste -- perhaps only 1-2%. (This may be an underestimate because it does not take account of 'unofficial' totting at civic amenity sites and landfill.)

Many industries already use a high proportion of their own waste as secondary raw materials, and indeed, in some cases

(eg glass) recycling actually forms an integral part of the production process. It is clearly important to understand how the materials are processed to see whether material from post-consumer waste could be accommodated.

I have listed some of the main trade associations involved with materials reclamation and recycling in Figure 4. Together, these groups form a very powerful lobby.

Paper: The printing industry and paper and board product manufacturers consume around 10 mt of paper per year. 60% of this material is imported from abroad. (The figure includes imported finished paper and printed matter.) The industry is dominated by powerful multinationals (Reid and Bowater). Over half of UK production of paper and board (57% in 1988; 2.4 mt) is made from waste paper (including paper and laminated board). Around 85% of this comes from established commercial waste paper industry sources.

The interests of the waste paper industry are represented by the British Waste Paper Association (with around 100 members), the Independent Waste Paper Processors' Association (with half that number), and a couple of large independents (Davidsons and Maybanks). New capacity is currently being installed to handle waste paper (on Merseyside, and in South Wales and Scotland), but this is not yet on line.

Glass: 275,000 tonnes of glass were recycled in the UK in 1988 (including glass recycled within industrial and commercial organisations). This represents some 16% of total production, and an increase of 100% on the figure for 1983. Some cullet (broken glass) was also imported. The glass comes from around 3,600 bottle banks located in some 1200 towns, and a further 2,500 operated by commerce and industry.

The figures are modest compared with those in other European countries. 30.5% of glass produced in Western Europe as a whole in 1987 (some 3.56 mt) was recycled, with the highest percentages in Switzerland (47%), Austria (44%), Belgium (39%), Italy (38%), and West Germany (37%).

Britain could recycle more glass, but how much more is not clear. At significantly higher recovery rates, careful consideration would need to be given to the colour balance. (UK glass container production is approximately 70% colourless, 30% coloured, and yet over 50% of the cullet from bottle banks is green.) Recycled glass fetches £20-30 per tonne depending on location, purity and the degree of colour separation. The market for cullet is relatively stable compared to that for paper and tin plate.

Ferrous Metal: In 1987, Britain consumed some 11 billion cans, including about 5 billion used for drinks, 4 billion used for other foods and pet food, and 2 billion for paint and other goods. Most were made from tin plate.

At present, very little tinplate is being recovered from post consumer waste and recycled. The process has not been considered to be economically viable. However, a small detinning plant was opened at Hartlepool in 1986. The owners (AMG) claim that this plant is profitable, and that further plants are planned. However, there are clearly high costs associated with transporting scrap to the plant, and efforts are being made to increase the local supply.

British Steel has said recently that it can now take up to 100,000 t/y of incinerated steel cans for recycling at its South Wales and Ravenscraig furnaces, but this is less than 1% of total iron and steel consumption (around 15mt/y). The capability of the British steel industry to absorb extra scrap is limited; its blast furnaces cannot take more than 40% scrap, and in practice it's nearer 20%. (Several foreign steel industries use arc furnaces which can accommodate more scrap.)

Aluminium: Aluminium is used in almost half the beverage cans sold in the UK (45% in 1988). (Roughly half were used for beer, the rest for soft drinks.) Perhaps 1% of these cans are recovered for recycling, which is low compared with, say, Sweden (where it may be as high as 85%), although there are special reasons for this. Cans account for less than half of the aluminium in MSW; the rest is foils and utensils, and some of these contain significant amounts of other materials (such as iron) which could reduce the value of the recovered material.

Plastics: Well over one million tonnes of plastics are used in packaging (1.3 mt in 1985), equivalent to about 2% of UK oil use. A roughly equivalent quantity of plastics are used for other purposes (in the construction and electrical/electronics industry, transportation, etc.). It is estimated that 90% of pre-consumer scrap generated within the plastics industry is recycled. Overall, however, only about 5% of plastics used in the UK incorporate scrap. Recovering plastics from MSW may not be practical (see section 3.5).

2.5 The Waste Disposal Industry

Waste disposal, especially landfill, is lucrative business. The field is dominated by a small number of large disposal companies which own many of the prime sites. (The main ones are listed in Figure 5.) Indeed, many mineral extraction companies have transformed their operations in recent years, away from simply providing void space to local authorities to offering a full range of disposal services, including the generation of energy.

2.6 Local Authorities And Voluntary Groups

Apart from being responsible for waste disposal, many local authorities have also been involved in materials reclamation, often in partnership with local voluntary

groups and charities. Some door-to-door schemes have been reasonably successful in the past; but most have now been wound up because of high costs -- although a few local authorities are experimenting with it again, in view of public pressure for recycling.

The majority of existing schemes are built around recycling centres -- the 'Save Waste and Prosper' scheme in Leeds is a good example (Wright, 1989). There's a great deal of experience with bottle banks, and there is now growing interest in the use of paper igloos and can-saver schemes.

Diversity of Views

With such a diversity of interests, it is not surprising that attitudes towards reclamation and recycling vary a great deal, even amongst those which actively support it. Voluntary groups tend to favour kerbside collection; whereas local authorities and the scrap trade go for recycling centres. Some prefer mechanical separation -- most notably the steel reclamation industry, and those who advocate waste derived fuel.

3 CONTENTIOUS ISSUES

In this section, I have attempted to summarise the main contentious issues in the recycling debate. Unfortunately, as I said at the start, the issues are fiendishly complex and involved. There is no single approach which is right for all situations. Indeed, it is sometimes positively dangerous to generalise because of the over-riding importance of a) local circumstances, and b) the market. In packaging, for example, there are some situations where glass is better than plastic; and there are others where the reverse is true. The same goes for paper, and ferrous and non-ferrous metals.

What worries me is that there is now such pressure to increase recycling that some very bad decisions could be taken. Some measures could be counter productive and involve the use of more materials or energy than can be reclaimed. Many of the decisions that are being taken appear to be more the result of intuition than careful analysis. And with recycling, intuition is not always a good guide.

Ian Boustead comments in a recent paper:

"Given the dearth of reliable information describing liquid food delivery systems, it is surprising that so many specific decisions have been taken in various countries in the name of environmental protection. It is difficult to escape the view that many of these decisions are the result of well-meaning emotional arguments, personal but unsubstantiated conviction or simply the expediency of solving a single, immediate, pressing problem." (Boustead, 1989)

The Secretary of State for the Environment, Chris Patten, announced at the recent Conservative Party Conference that 50% of domestic waste should be recycled by 2000. This, to me, looks like a hopelessly impossible target -- unless you include the 30% moisture content! We will have to wait and see how he intends to achieve the feat. (My understanding is that the Minister misread his brief, and should have said 50% of the material that is capable of being recycled would be recycled by 2000.)

3.1 Does Separation at Source Work?

Kerbside Collection1: It has proved difficult to make kerbside collection schemes profitable because of high capital and labour costs. The fact that many reclaimed mater- ials command only low market price makes matters worse. At current scrap rates, a wine bottle and an aluminium can are only worth about a penny each. It is therefore necessary to collect large quantities in order to offset the increased cost -- even allowing for some financial credit for avoided waste disposal costs. (It takes 50,000 aluminium cans to make up a tonne, which may fetch £500 -- if the cans are clean.)

Moreover, materials that are collected are often mixed or contaminated, which makes recovery even less profitable. (Removing metal caps and rings from glass bottles is expensive: a glass processing unit built recently at Harlow cost around £1 million.) Mixed cullet has very little value.

Extra staff may have to be taken on, collection vehicles modified or replaced, and extra bins provided for householders. There are also storage costs to be considered; the waste streams must be kept separate and measures taken to protect against fire and vermin. (The requirement for two or more bins may also present problems in modern homes where space is at a premium.)

Separation at source also requires the public to be discriminating. It is not always easy to decide what should be included in a recycling sack, this is a particular problem with some paper products, which have been plasticised or contain unsuitable glues. The separation of plastics cannot realistically be carried out by untrained individuals.

And if only two bins are used (as is now being proposed in the 'Recycling City' initiative at Sheffield), there still remains the problem of separating out the cans, bottles and papers after the collection. (At Sheffield, the plan is for people to put paper, glass, cans, etc. in blue boxes, and for them to put these out when they are full. The items would then be separated by the collection staff and put into separate containers on the truck. It remains to be seen whether this approach is practicable.)

At the very least, operators should receive payment for the avoided cost of waste disposal as a result of removing material from the waste stream. Even so, kerbside collection may still only make sense when carried out by voluntary groups with low labour costs.

Recycling Centres: Bottle banks, can-saver schemes and paper igloos can provide a useful return to the operator, provided the market doesn't get flooded -- as has happened frequently with paper. They can also save processing energy. Each tonne of cullet returned to the furnace may save energy equivalent to 25% of that used to make 1 te of molten glass. For waste paper, and scrap iron and aluminium, the savings can be considerably greater.

The best bottle banks achieve 40% recovery, but most schemes are far less effective. (There is less experience with paper igloos and can-saver schemes.) 15-20% reclamation is probably as far as one can go with a voluntary separation recycling scheme.

There has been some opposition from local authorities because collection points can cause public nuisance as a result of noise and fly-tipping. Clearing up litter and debris from around sites involves additional costs.

The economics of recycling centres are very difficult to assess. With bottle banks, cullet becomes the subject of the glass industry's internal financing system. Glass manufacturers exercise tight control over the market. (The bottle banks themselves are operated by a variety of organisations, some sponsored by the industry.) There are problems in assessing the economics of paper and ferrous metals because the markets are so volatile. There is no doubt that some recycling schemes are heavily subsidised and only continue because they provide good PR for the industry. In these cases, the greater the level of reclamation, the greater the losses incurred.

Recycling centres can work, but they must be very carefully sited. If people make a special journey to deposit items in the bins, the energy expended makes the whole exercise a nonsense. (In terms of energy use, kerb-side collection is actually far more economical.) The best sites are car parks close to city centres or supermarkets. A dense network of locally sited mini-skips may also be justified.

Reverse vending machines have been tried as a means of encouraging cans to be returned. They dispense tokens or coins in return for 'empties'. However, they have not been totally successful because of technical problems and vandalism. They appear to work in Sweden, but are more problematic in countries like Britain where large numbers of (low value) steel cans are used.

3.2 Is Packaging A Waste?

Packaging accounts for about a quarter to a third by weight of domestic waste, and considerably more by volume. It has been a major focus of attack by environmental groups, who claim that much of it is unnecessary. One fifth of plastics used in Western Europe have a lifetime of 1 year or less. The lifespan of some fast-food packaging is measured in seconds.

The packaging industry argues that there is no such thing as 'unnecessary' packaging, since all packaging serves some function -- even the plastic tray in a chocolate box. Manufacturers are not fools! But who is to decide whether the particular function justifies the consumption of resources and the environmental damage caused?

Packaging provides containment and protects goods from damage during transit, storage and handling (from physical shock, corrosion, heat and cold, light, contamination, or infestation). It therefore reduces wastage, especially in the food industry (which saves a great deal of energy). It may deter tampering or theft (eg the use of bags in large stores to indicate proof-of-purchase, or bubble packs on small, high value items like batteries to deter shoplifting).

Packaging may also provide useful or important information to customers; it identifies the brand, the content and the quantity, and may also contain instructions on safety. It may help with dispensing, and assist with marketing (by catching the shopper's eye).

Modern packaging is often highly economical in materials. However, the economies have been achieved by combining different materials in one pack, making it more difficult to recycle the constituent parts. The paper carton illustrates this well: it is laminated paper and plastic, and may also contain foil.

Some forms of once-through packaging may be ecologically more sound than alternatives, for example, beverage containers made from plastic and or paper, since they are lightweight, will pack more tightly, and involve less energy to manufacture, and lower transport costs. They may also be more hygienic, and can be burnt after use, and energy recovered.

One recent German paper (Pllehn, 1988), for example, shows fairly conclusively that in terms of energy use and environmental emissions, bags made from polythene are considerably better than bags made of paper.

Some would argue that it is more important to conserve energy than to conserve materials, because of the limitations on the resources and the environmental problems that are caused by generating and using energy. On balance,

I agree with this.

3.3 Which Beverage Container?

Bottles, Cans, and Cartons: When it comes to a choice between different forms of packaging, say for beverage containers, many factors must be considered. First, there is the question of the type of container (bottle, can, or carton), and the most appropriate material to use (glass, plastic, paper, steel or aluminium). Some combinations are immediately ruled out, such as bleach in glass bottles, or fizzy drinks in cartons. But for many goods, several approaches are possible.

Second, there is the question of whether containers should be designed to be thrown away after use (with the hope that they will be deposited in a bottle bank or can-saver skip and recycled), or whether they should be designed to be returned to the vendor, cleaned and reused. In which case, they have to be more heavily built.

Materials and Energy: Over the years, considerable effort has gone into analysing these different options in terms of materials and energy use. Needless to say, interpreting and comparing such studies is difficult because of the nature of the assumptions made, for example, about

o how large a container is, and how often it is used;
o whether the container is reused or recycled -- and if the latter,
o what percentage of those produced are recovered;
o the nature of the industrial processes;
o the location of the manufacturing plant, and
o the distance goods and reclaimed materials are moved;
o whether heat recovery is considered (for paper and plastic products); and
o whether a particular collection procedure is commercially viable and acceptable to the public (without whose active support very little can be achieved).

It is not difficult to show that returnable glass bottles can be very energy efficient, for example, when used by publicans and the hotel trade, or for doorstep milk delivery, where most bottles are returned, and the average trippage is high. (About three quarters of beverages that go into glass bottles go into reusable bottles.)

However, the benefits are less clear-cut where reusable bottles are sold to the general public via corner shops, because a significant proportion are simply not returned. (The British Soft Drinks Association reckons that consumers forfeit £20 million each year in lost deposits.) The switch from small local bottling plants to large centralised ones has made reusable bottles less attractive.

Cans, plastic bottles, and cartons are more appropriate than glass for long distance transport because they are light --

although an alternative approach would be bulk transport and local bottling. (This latter option may not be permitted by law, as is the case with mineral water in the European Community.)

The moral is that each scheme must be considered on its merits.

3.4 Should Recycling be Mandatory?

Some people have advocated using deposits or mandatory measures to improve the return rate. But there are some doubts whether this works in practice.

US Experience: Oregon pioneered the first legislative ban on non-returnables in 1972, and since then, bans on easy-open beverage containers and or mandatory deposits have been introduced in nine States (Vermont, 1975; Michigan, 1978; Maine, 1979; Iowa, 1970; Connecticut, 1980; Delaware, 1982; Massachusetts, 1983; and New York, 1983).

However, over the last six years only New Jersey has adopted a mandatory scheme for waste management (which does not include deposit legislation), and initiatives in eight other states (Alaska, Arizona, California, Colorado, Montana, Nebraska, Ohio, and Washington) have been defeated. One study showed that consumers in deposit law states had to pay considerably more for canned drinks and had less choice than in non-deposit states; another concluded that it would be many times more effective to put deposits on newspapers than on drinks cans.

Deposit Legislation in Europe: The European Commission is planning shortly to introduce a Directive on Containers of Liquids for Human Consumption (which has been under discussion since 1985). The UK Government has been strongly opposed to mandatory measures being imposed.

What impact the Directive will have, when it is introduced, remains to be seen. But there has been some suggestion that other leglislation has been used as a barrier to free trade, for example, Denmark's ban on the sale of beer and soft drinks in non-returnable containers -- recently upheld by the European Court -- which protects domestic producers against imports (Denmark still exports non-returnable cans); Ireland's attempts to ban cans for beer sold in the Republic (where most beer sold is draught); and Germany's decision to impose a hefty 50 pfenning deposit on plastic drinks containers, which has severely affected trade in French and Belgian mineral waters. The deposit (which is considerably more than the value of the container), does not apply to plastic containers for milk.

The indiscriminate use of legislation can be counter productive, since it can lead to the accumulation of vast surpluses which drives down market prices and puts small companies out of businesses. This happened with waste paper

in Germany in 1986, and it is happening now in the US. Merchants on the Eastern Seaboard are actually being paid to take paper away. It is being exported to Europe at vast expense -- which is hardly an environmentally sound approach!

3.5 Plastics: Should They Be Recycled?

As a packaging material, plastics have a lot going for them. They are cheap, light-weight, and strong, which means that comparatively little material can be used. Plastics can also be designed to be flexible, rigid, unbreakable, insulating, crushable, or transparent, depending on the application. The total feedstock and production energy for a plastic container is sometimes less than just the production energy of other types of container.

Thermoplastics like polyethylene, polystyrene, PVC, and PET can in principle be recycled. The problem is that they are difficult to classify, separate and clean, and very expensive to store because of their exceptionally low bulk density. They also have a low resale value. One would have to collect 250,000 polystyrene cups, or 300,000 plastic bags to make a tonne of plastic, worth no more than a few hundred pounds -- if the material is clean. (Typical values for virgin polymer are between £500 and £600/t for polythene, around £750-850/t for PVC, and £1,000-1,200/t for PET.) What's more, if separation is incomplete, and PVC contaminates any of the other plastics, it can ruin a complete batch.

There are many different kinds of companies involved in the manufacture of plastics, rather than a single industry, as for glass. and this is an added complication.

There may be a case for recycling some of the more expensive forms of plastic in post-consumer waste, such as PET, although I remain to be convinced. (Schemes do already operate in, for example, Italy and the US.) But for most plastics, recycling does not seem worthwhile. It is probably better to incinerate the plastic without separation under carefully controlled conditions, and recover the embedded energy as steam or electricity (see section 3.7). With the exception of PVC, all plastics have a high calorific value, roughly equivalent to that of oil.

3.6 Paper: Fibre or Fuel?

The UK consumes around 10 mt of paper and board each year. The major components of this are wrapping papers and packaging board (36%), printing and writing paper (29%), and newsprint (17-18%). Tissue paper accounts for 7-8%, and the remainder (10%) is used in a wide range of specialist papers and board. Approximately 60% of this material is imported, along with significant quantities of finished paper and board products.

Waste paper has two potential applications: it can be recovered and recycled as fibre, or, alternatively, left in post consumer waste and used as fuel. These two approaches are often seen as mutually exclusive, whereas in reality they can be complementary.

Recycling paper as fibre incurs significant collection and processing costs -- deinking is expensive -- but reduces disposal costs and the need to grow and cut timber -- which in turn may require fertilizers and pesticides -- and the need to import so much virgin pulp.

Recycling paper as energy -- it has a calorific value around two thirds that of coal -- reduces the need to burn fossil fuels or use nuclear power, which also has a net benefit on the environment. It also avoids the cost of separate collection and processing, but may itself incur significant costs, for example if incineration is used for heat recovery. (Combustion also helps to destroy putrescible material, toxic chemicals, and pathogens that might cause problems in landfill.)

I have already mentioned that large quantities of waste paper and board are already collected and recycled in the UK. In 1988, recycled paper amounted to some 2,454,000 t (including imported material). It is believed that about 5 mt could in principle be recycled. In practice, as with all aspects of recycling, the issues are complex, and the economics uncertain.

It is obviously more profitable to collect high grades of paper, which can substitute for virgin pulp, especially since these are often available clean from factories and offices. Lower grades too can be recovered from commercial premises. But recovering post consumer waste paper from the domestic sector is more problematic because of the low value placed on mixed paper waste, problems with contamination, and the volatility of the pulp market.

The main potential for recycling seems to lie with printing, writing and tissue paper, which together account for 36% of consumption (2.7 mt). A major part of newsprint and board already comes from waste (64% and 78% respectively in 1985). But to achieve higher incorporations could involve some loss of quality, and will only be possible if there is a change in consumer attitudes. An alternative would be to export more paper overseas. (Exports are rising, and are currently around 450,000 t/y.)

How far one can go down this route is unclear, because the more paper that is recycled, the lower the average grade of the waste produced, the more difficult recycling becomes next time round, and the smaller the economic returns.

Today, the market for waste paper has collapsed, and some voluntary groups are being offered just £5/t, which cannot justify the time and effort which goes into collection. (A

more typical figure would be £10-20/t, with merchants getting perhaps around £40/t at the mill.) At these prices, paper is worth a lot more as fuel than as fibre.

Changes to Calorific Value: But even if paper recovery from post consumer waste is taken to its practical limit there would still be significant potential for recovering energy from waste. If a major recycling initiative succeeding in removing 30% of paper, 20% of plastic, 50% of glass, 15% of ferrous metals, and 15% of non-ferrous metals, it would only reduce the calorific value of MSW by a fifth.

3.7 Energy From Waste: Which is the best option?

Three possible routes for recovering energy from waste have already been mentioned: landfill gas, mass burn incineration, and waste derived fuel. To some extent, the technologies are in competition. Each has its attractions and its drawbacks -- not to mention its champions and detractors.

Landfill Gas: Landfill gas extraction is considerably cheaper than mass burn incineration, and much quicker to implement. A new site, properly lined, and carefully controlled could charge £10-15/t for disposal (excluding transport costs, which could add up to £20/t or more for long hauls). However, it relies on a biological process and is much less efficient than incineration in terms of energy recovery. There are also lingering concerns over possible threats to ground water, and potential local problems with nuisance through noise, smells, litter, vermin, and heavy traffic.

Incineration: Incineration can provide 4-6 times as much recoverable energy as can be obtained by tapping gas from landfill. (This includes energy from plastics which are not broken down in landfill.) Moreover, some materials (especially iron and steel) can be recovered relatively easily using magnets. It destroys pathogens and many toxic chemicals, reduces the volume by three quarters or more, and produces a biologically inactive residue. It also permits better control over environmental emissions, and is easier to monitor than landfill.

However, incineration is far more expensive. A new mass burn incinerator equipped with heat recovery and flue gas scrubbers could cost £40-45 m. It would need to charge a gate fee of £25-35/t to break even. The scrubbers can reduce emissions of particulates, heavy metals (like lead and cadmium), and dioxin to very low levels, provided they are properly maintained. Incinerator ash is toxic and requires careful treatment.

Waste Derived Fuel: Waste derived fuel (WDF) has a more consistent nature than raw refuse. It is easier to handle and store, and presents less of a health risk. However, it is a comparatively low grade fuel with a low bulk density

and expensive to produce. It also has a relatively high ash and chloride content, and tends to go mouldy and rot if it gets wet. (It also spontaneously heats up if stored in large piles because of composting, and can present a fire risk.) But the biggest problem with WDF has been finding suitable markets for the fuel.

4 OBSERVATIONS AND CONCLUSIONS

I should like to conclude by summarising my general observations about various aspects of the reclamation and recycling debate.

The Potential for Recycling

1. Britain has a large and well-established reclamation industry, with a turnover in excess of £2 billion a year. 56% of all iron and steel consumed, 25% of paper, and 16% of glass, comes from scrap. Aluminium and plastics are also recycled. But very little material is recovered from municipal solid waste (perhaps 1-2%); another 2% is recovered as energy, primarily through incineration. The remaining 97% is dumped unproductively in holes in the ground, or burnt without energy recovery. This involves a massive waste of natural resources and is a cause of serious environmental problems.

2. Half of the material in municipal solid waste is probably recyclable, including paper, glass, and ferrous and non-ferrous metal. Most plastics are probably not worth salvaging, and are better burnt in mass burn incinerators equipped with energy recovery.

3. There is scope for industry to take more reclaimed material. However, it is not always possible to replace virgin material entirely. Using additional secondary material may present technical difficulties, involve major expenditure (because new capacity is required), or involve a fundamental change in organisation and operation. It may also lead to some loss of quality in the product, although this may not be of any great consequence (eg the use of recycled fibre in tissue paper).

4. If targets for recycling are introduced -- and I believe they should be -- industry must be given sufficient time to reorganise its operations. The national as a whole will benefit, and so too will the environment. Compensation may therefore be appropriate.

Establishing Priorities

5. Reclamation and recycling look more attractive today as a result of advances in technology, which have improved the feasibility and economics of recycling. Public attitudes have also changed. However, there is a real danger that politicians will react to public pressure by introducing

measures that are counter-productive. Recycling may 'save' some mineral or other, which is not in particularly short supply (bauxite, sand, limestone, etc.), at the expense of some other resource which is more highly valued, such as oil or gas.

6. Any assessment of the desirability of different recycling strategies must make explicit value judgements as to the relative importance of different resources (ores, as well as renewable and non-renewable energy), and the environmental impact associated with their use and disposal. Otherwise it is not possible to make sensible choices.

7. Similar reasoning applies to packaging: does the particular service that is being provided (protection of food, the provision of information on safety, the display of a brand name, etc.) justify the materials and energy that are consumed, and the environmental damage that is caused? One also needs to consider who it is that benefits, the producer, the seller, or the customer?

Separation Techniques

8. The most promising approach to reclamation from post-consumer waste is via separation at source, rather than mechanical recovery from mixed waste. This applies to all materials except iron (which can readily be recovered from pulverised waste using magnetic separators).

9. Recycling centres (bottle banks, paper igloos, can-saver skips) appear to be more workable than kerbside collection, despite a number of obvious drawbacks (such as littering, noise, and siting difficulties). A combination of large centralised units (eg in supermarket carparks) and a dense network of mini-centres appears to be the best strategy.

10. Recovery rates of 15-20% are probably the best that can be expected with voluntary schemes, with 30-40% in exceptional circumstances.

Measure to Encourage Recycling

11. The best way to increase resource reclamation is to see that secondary materials are properly valued. At present, little or no account is taken of the fact that resources are saved and environmental damage reduced. At the very least, recycled materials should be credited with the avoided cost of disposal to help offset the higher costs of collection, separation and processing. Average rather than marginal costs should be used.

12. There may also be a case for discouraging the use of virgin materials -- especially where they are imported -- through such mechanisms as introducing directives on the use of recycled materials (eg in paper). The Government, local authorities, and commerce and industry, could all play a

role here. Whether it would be appropriate to impose levies to reflect the fact that the extraction and processing of raw materials has an adverse impact on the environment needs to be looked at. (There may be problems here because of Common Market laws on free trade.)

13. Whether recycling should be made mandatory or not needs to be looked at very carefully in the light of past problems with markets being flooded with materials for which there were no ready outlets. The best way to avoid surpluses is to ensure that there are markets for recycled materials -- which is also the best way to make recycling schemes successful.

Containers

14. Using returnable containers can prove highly worthwhile from the point of view of resource use, provided there is sufficient trippage to offset the increased materials and energy required for their heavier construction. In practice, returnables used by the catering trade and in doorstep milk delivery do achieve high trippage rates, but the trippage for many returnable containers has been falling (even though deposits are used).

15. Unless one has a clear idea of the relative worth of different resources (ores, and well as non-renewable and renewable energy), it is not possible to identify one container type as better than any other.

Materials Versus Energy

16. Recycling can save energy, although not in all cases. Whether there are savings depends on how much additional energy is required to collect the waste material from the user, separate, clean and process it, and then transport the purified secondary material to the manufacturer.

17. Materials reclamation and energy from waste are not mutually exclusive options, given the level of recovery that can be achieved in practice. In terms of energy recovery, incineration is to be preferred to landfill gas (it is 4-6 times more efficient). However, incineration is considerably more expensive, especially given the high level of control on emissions that is now required, and there is likely to be problems in winning public approval for new schemes.

18. Waste derived fuel does not look too promising at present: there have been problems with its manufacture and combustion, and difficulties in persuading industry to use it.

Research

19. There are many questions relating to reclamation and recycling that cannot yet be satisfactorily answered. For example, very little work has yet been carried out to

ascertain and compare the full environmental impact of different recycling strategies (including those where items are used only once but where energy is recovered).

20. Further research is also needed into suitable and acceptable mechanisms for increasing the recovery rate associated with separation at source schemes; and on determining how society should assess the relative importance of materials and energy, and quantify the impact that the production of both has on the environment.

Fig. 1: Packaging In Waste On Merseyside (1980)

	non-packaging (by wt)	packaging (by wt)	Packaging as percentage of all waste (by wt)
Paper	80.2%	19.8%	6%
Glass	7.1%	92.9%	8%
Metal	4.2%	95.8%	7%
Plastic	11.4%	88.6%	4%
		Total	25%

Source: INCPEN

Fig. 2: UK Market For Packaging Material by Value (£million) (1985)

Plastics	1,010
Fibreboard	746
Cans	713
Glass	415
Board	256
Paper	222
Paper sacks	112
Steel drums	111
Aerosols	85
Wooden containers	57
Miscellaneous	132.5
TOTAL	3,894.5

Source: Materials Reclamation Weekly

Fig. 3: Use Of Scrap In The UK (1988)

	Consumption (t)	Production (t)	Scrap Use**** (t)	Export (t)
Paper & Board	9,970,000*	4,317,000	2,454,000	424,000
Steel & Iron castings	15,860,000	20,360,000	8,860,000**	3,609,000
Aluminium	525,000	406,000	131,000***	114,000
Glass (from containers)	1,750,000	1,728,000	275,000	3,000
Plastics	3,250,000	1,911,000	150,000	na

	Scrap Use as Percentage of Consumption	Production
Paper & Board	25%	57%
Steel & Iron castings	56%	44%
Aluminium	25%	32%
Glass (from containers)	16%	16%
Plastics	5%	8%

Notes:
* including imported printed matter and converted products
** includes in-house scrap recycled within producers own works
*** excludes metal loss by oxidation in remelting
**** includes imported scrap

Source: Warren Spring Laboratory

4: Organisations Involved With Recycling

Professional Bodies and Trade Associations

o Aluminium Can Recycling Association
o Aluminium Foil Containers Manufacturers Association
o British Glass Manufacturers Confederation
o British Scrap Federation
o British Paper and Board Industry Federation
o British Plastics Federation
o British Steel Corporation
o British Waste Paper Association
o Independent Waste Paper Processors' Association
o Industry Committee on Packaging and the Environment
o Institute of Waste Management
o Liquid Food Packaging Association
o Packaging Council

There are also two coordinating bodies:

- o the United Kingdom Reclamation Council
- o the Bureau International de Recuperation (BIR).

The Reclamation Council was formed in 1984 to bring together all organisations concerned with waste reclamation, recycling and waste management to "enhance their efforts in protecting the environment and stimulating economic resource recovery schemes".
The Bureau International de Recuperation has dealings in around 50 countries in North America, Europe (including the communist block), the 'old Commonwealth' and some Third World countries.

5: Major Private Waste Management Companies

- o Shanks & McEwan
- o Biffa
- o Hales Containers
- o Waste Management
- o Cory
- o ARC
- o BCI Landfill
- o Cleanaway
- o Leigh Interests
- o Wimpey Waste
- o Drinkwater Sabey
- o Econowaste
- o Hargreaves

REFERENCES

Barton, J et al (1985): 'Waste Sorting and RDF Production in Europe', Elsevier Applied Science Publishers, London/New York

Barton, J (1989): 'Recycling and Packaging: Source separation or centralised treatment', Paper to Institute of Waste Management Symposium, London, 4 October 1989

Bickerstaffe, J (1988): 'The Resource Equation', Warmer Bulletin No 18

Bickerstaffe, J (1989): 'Taking the Strategic View - Packaging into the 1990s', Paper to conference on 'Packaging and the Environment', London, 19 May 1989

Bowstead, I (1989): 'The Environmental Impact of Liquid Food Containers in the UK', INCPEN, London

Brown, A et al (1988): 'Energy Recovery Through Waste Combustion', Elsevier Applied Science, London

Cooper, J (1988): 'Disposal of Household Waste', in 'Is Plastics Packaging Rubbish?' one day conference organised by Rapra Technology Ltd and PIRA Packaging Division, Forum Hotel, London

Cooper, J (1989): 'Meeting the Demand: Local authorities promotion of reclamation', Paper to Institute of Waste Management Symposium, London, 4 October 1989

Environmental Resources Limited (1985): 'Resource Recovery: a report to the Royal Commission on Environmental Pollution', HMSO

New, R (1986): 'Plastics Waste Recycling in the United Kingdom - a position study', Warren Spring Laboratory, Stevenage

Pllehn, W (Ed) (1988): 'Comparison of the Effects on the Environment from Polyethylene and Paper Carrier Bags', Federal Office of the Environment, Berlin

Richards, K (1988): 'The UK Landfill Gas and Municipal Solid Waste Digestion Industry', Energy Technology Support Unit, Harwell

Stonach, NJ (1988): 'Energy from Municipal Solid Waste: The future?', Energy Technology Support Unit, ETSU-L-24

Tron, A R (1987): 'Recycling of Wastepaper in the UK - an overview', Recycling Advisory Unit, Warren Spring Laboratory

Vogler, J (1985): 'Plastic reclamation in Europe: Recent developments and trends', Pira Seminar, 'Cellulose Fibre and Plastics Recovery - Potential for Growth', Leatherhead, 19 November 1985

Waste Management Advisory Council (1976): 'Study of Returnable and Non-returnable Containers', for the Department of the Environments and Industry

Wright, G (1989): 'Waste Recycling in Leeds', Paper to Annual Conference, National Society for Clean Air, Scarborough 23-26 October 1989

LOCAL AUTHORITIES: GREEN INITIATIVES IN ACTION

ENERGY EFFICIENCY

By

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Harlow District Council

The practical approach to energy efficiency in Harlow has gone through a number of stages. In this paper I hope I can give a flavour of the development of that process.

Success in energy efficiency applications is not always the one off innovation, it is mostly the dogged determination to push and keep pushing for continual improvements. In the same way it may not always be the high technological examples which give the greatest reward, it may be just good housekeeping and discipline which give the best effect.

1979 - 86

Energy conservation for Harlow Council started in 1979 when a group was formed principally to deal with the effects of the oil crisis. This group initially set out to safeguard supplies of oil to Council buildings. It then developed into an Energy Group and looked at a wide number of issues Council wide, under the following headings.

1. Building Design

    The need to incorporate higher insulation provisions in the design of building, we have now had incorporated into timber framed buildings, together with high insulation levels into new housing and leisure projects.

    We commissioned an experiment with a solar panel on one dwelling and in comparison with an identical property we found that to be cost effective it would require a 10-year pay back period. It proved difficult to justify for use in a domestic property.

    Schemes with southern orientation, passive solar gain, and a heat pump have been included in our housing programme with more cost effective results in reducing energy requirements to a minimum.

2. Council Buildings

    At the Swimming Pool we were involved in recommending the change of heating from oil to gas. The

installation of a run-round heating coil produced a saving of 35% in gas consumption. Solar Panels, a heat pump and a cover for the pool were all looked at and were found not to give effective pay back period. However, when the ceiling of the Pool was removed to renovate the steelwork it was possible to insulate the roof and improve the lighting efficiencies when it was replaced.

At the Town Hall we looked at double glazing which was rejected. Solar Panels and the use of waste heat from the computers was also not found to be a viable proposition. However, draught stripping to the metal window frames did proceed and was reasonably effective. When the Civic areas in the Town Hall were refurbished the new lighting was designed to give better illumination standards and be low in energy consumption.

3. Council Vehicles and Fuels

One of the other tasks was to monitor the fuel consumption of the Council's vehicles and plant. The overall usage being compared with the number of vehicles in each Group and the total mileage.

There was a significant change in the make up of the vehicle fleet over the years. During that time we looked at and recommended the use of liquid petroleum gas (LPG) vehicles. We also evaluated electric vehicles as new models became available.

We did much of the background work for a Good Driver Award Scheme which is now held each year.

1986 onwards

In 1986 I was able to combine a number of initiatives together which led to a comprehensive review of Energy Conservation in the Authority.

We had commissioned the sevices of an Officer of the Council outside the original group to look at the way in which we tackled energy matters. His conclusions were that the following were needed:

1. A stated Council Energy Policy.

2. Monitoring arrangements to check and publish savings achieved.

3. Tariff checking on the major Public Utilty charges.

4. Wider staff awareness of energy in use, and measures needed to be taken in conservation.

The Audit Commission were at the same time preparing a

report on the Council's work in this field. They produced a statistical comparison of the financial performance of a selection of Council buildings with a sample of similar buildings nationally.

At the time the Department of Energy were offering a free consultancy service for a consultant to visit authorities and look at specific buildings and their conservation needs. I therefore used this to cross check the Audit Commission's findings.

This gave sufficient conclusive evidence to convince Council members that investment in Energy Conservation was justified and beneficial in economic savings terms.

The Audit Commission had already suggested in their report a recyclable fund of monies which could be used for investment. This meant the initial savings being paid back into the fund until the costs were recovered and thus enabling reinvestment thereafter.

At the same time the Council agreed to an additional post for monitoring of savings and this allowed the Energy Group to re-emerge with a new dimension.

The first plank in the new strategy was the Council Policy which stated:

"Harlow District Council accords high priority to the efficient use of energy in all its activities and will ensure that:

a) All new buildings and operations are as energy efficient as practicable.

b) All existing buildings and/or activities are improved, where possible, to a level of maximum achievable efficiency in a reasonably economic manner.

c) Relevant training will be given to all employees concerned with the use and control of energy."

It also established accountability with a reporting line through the Council's Perfomance and Efficiency Committee.

All the foregoing link the idea of energy conservation with financial savings. This is useful in establishing the type of initiatives I have just described. When the benefits are seen in financial terms it is easier to suggest investment in the not so economic but energy efficient schemes in the longer term.

Some of the initiatives we have been able to take since the Council decision in 1986 are very interesting both in energy conservation and organisational terms.

1. Building Prototypes

Using the Audit Commission's list of buildings and the Department of Energy consultants' comments, we proceeded to use improvements to these buildings as prototypes for other applications in similar properties.

Such examples are:

Swimming Pool	-	Separate heating runs on Learner and Main Pool.
		Combined Heat and Power equipment water temperature adjustments.
Playbarns	-	Boiler and Lighting Controls
		Showers were installed to replace the use of baths.
		Lighting improvements.
Museums	-	Boiler and Lighting controls.

2. Other Projects

Following on from these experiences there have been other ideas for schemes for energy saving which have been implemented such as:

Public Toilets	-	Lighting improvements and Control.
Sheletered Accommodation	-	Recycling waste heat for a refrigerator unit.
-	-	Night time temperature adjustments.
Car Parks	-	Lighting upgrading and control.
Boiler Efficiency	-	Use of calibrating heater.
Electrically Centrally Heated House	-	Monitoring comparative costs.

Tariff Checking

One of the major areas of cost saving is the checking of tariffs. By ensuring that the Authority is paying for the fuel at the most economic rate, bills can be optimised.

We did use the services of a company specially set up with expertise to carry out this task. However, the extent of

their recommendation did not give the major boost some expected.

The breakthrough which we have made is in the Gas area with the aggregation of bills in groups of property, and finally by the acceptance of a single contract for all the Council's supply to such buildings.

Staff Awareness

This area is of fundamental importance in monitoring the momentum of any initiatives. Mechanical controls help in the automatic setting of boilers, lighting and on/off times, but the people involved unless continually reminded will use manual over-rides, forget to switch off equipment, lights etc, and destroy the good which has been achieved by other means.

To this end we have tried to improve operating practices by issuing manuals, fact sheets and general publicity. We have also sponsored a suggestion scheme with prizes.

The next area on our agenda is to make a video which will form the introduction to wider briefing sessions for all staff.

As the old adage says: "a little and often".

LOCAL AUTHORITIES: GREEN INITIATIVES IN ACTION

WASTE RECYCLING IN LEEDS

By

Geoff Wright
Leeds City Council

Background

Like the majority of District Councils, Leeds ceased the collection of separated waste paper from householders early in 1977. Public and political concern prompted an examination of alternative means of giving environmentally concerned residents the opportunity to recycle their waste paper.

The conclusion was that the public may be willing to deliver their paper to collection sites which were staffed by volunteers providing the proceeds were passed on to charity.

In collaboration with the voluntary sector, a local waste paper merchant and the media, the first city-wide paper collections was held on 13 August 1977. Almost 100 tonnes of paper was delivered to 60 collection points on that day and £2,000 raised for a child leukaemia fund.

The Save Waste and Prosper (SWAP) Recycling Scheme was born!

Statistics

In the following 12 years, 35,868 tonnes of paper, glass, cans, aluminium foil, textiles and plastic bottles, together with 5,400 gallons of used motor oil have been diverted from the waste stream and £232,000 raised for local charities.

The amount of each material collected up to 31 July 1989 is as follows:

Waste paper	-	18,992 tonnes
Office paper	-	117 tonnes
Glass	-	15,937 tonnes
Cans	-	775 tonnes
PET bottles	-	33 tonnes
Foil	-	20 tonnes
Textiles	-	110 tonnes

Administration

The project is administered by a registered charity, the Leeds Recycling for Charity Committee and operations are directed by a non-profit making company, Save Waste and Prosper Ltd. Both bodies draw their membership from the three scheme sponsors - Leeds City Council, Leeds Council for Voluntary Service (now Voluntary Action - Leeds) and the West Yorkshire Waste Management Joint Committee.

The City Council is responsible for operations (with the assistance of the Waste Management Committee) and financial arrangements. Voluntary Action provide the secretarial services and liaise with the charities.

Three charities participate at any one time, each assisting with operations in a designated third of the City for three months. The proceeds are divided between the three organisations at the end of their quarter.

Economics

The City Council provides the staff for operations through the Environmental Health Services, and the Department of Finance provides the Treasurer. The estimated total cost, including on-costs and administrative services, is estimated at current rates to be approximately £24,000 per annum.

The Waste Disposal Authority provides storage and loading facilities for the cans collected through the scheme. All other costs such as site cleaning, transport, publicity, maintenance, insurance, etc., are taken out of the income from the sale of materials.

The net profits are covenanted by SWAP Ltd to the Recycling Committee for distribution to the participating charities. Through this arrangement, although SWAP has to pay tax on the year's trading, it is reclaimed by the Recycling Committee.

The return to the authorities involved lies not only in the reduction in domestic waste but also in the undoubted public relations value and the environmental education the project offers.

Operational Approach

The resources available have dictated that the operational approach has continued on parallel lines to the original paper collection, i.e. to establish collection sites to which residents are encouraged to deliver materials which accumulate in sufficient quantities to render their collection economically worthwhile.

Twelve years of continuous experimentation has led to two separate classes of collection sites.

Multi-material collection centres based at supermarkets, shopping centres or public car parks near to shopping areas are the most successful. These are aimed largely at the car driving shopper and twelve of these main recycling centres receive almost 70% of the total tonnage.

The bulk of SWAP sites are based in the local community with collection containers sited at schools, pubs, community centres, libraries, etc. These provide recycling facilities within walking distance for many residents. Often the small sites are uneconomic and are supported by the busier main sites, but they are regarded as a part of the service offered by the scheme.

Encouraging participation

Publicity is all-important. Campaigns aimed at raising the level of awareness of the scheme and the need to recycle have been conducted using leaflets and posters; press, radio and TV advertising, and regular press releases. Evaluation of individual campaigns has always proved difficult. Clearly regular publicity is the key and perhaps the most significant fact is that the tonnage collected has increased every year since 1977.

It is interesting to note, however, that a recent public opinion survey conducted amongst recyclers in Leeds revealed that most supporters first became involved after seeing the collection containers on site!

Materials Collected

Waste paper

This material has been the mainstay of the project since the first collection. The once a month collection was gradually converted to what is now a network of 140 permanent sites for newspapers and magazines. Many igloo-type containers are located at schools or voluntary organisations on a profit sharing basis with 75% of the income handed back to the sponsor and 25% retained by SWAP.

Office waste paper is collected through 110 wheeled bins located in Council and other offices. This is a relatively new scheme but has grown gradually and is now collecting an average of 2 tonnes of high quality office paper per week.

Glass

This is the other main material collected at 72 public and 48 commercial (restaurants, hotels, etc) sites. All the sites are now equipped with bottom emptying igloo type containers which removes the need for any intermediate storage.

Cans

The Save-A-Can project collects food and drink cans on 13 sites with the support of the Can Makers.

A project for the collection of aluminium drink cans has recently been set up in schools in collaboration with a local recycling company,

Plastic Bottles

The British Plastics Federation ran a pilot project for PET plastic drinks bottles in Leeds and Bradford for 5 years. For a variety of reasons, the pilot was not a success but some lessons were learnt and have helped towards the follow-up scheme recently launched in Sheffield.

Aluminium Foil

Foil was collected at the monthly sites for a while but it is not a material which lends itself to collection in containers in car parks.

It is now being collected in schools along with the aluminium cans.

Textiles

Textiles were also collected through the monthly collection for a few years. The quality received in this way was poor and as yet no alternative system has been developed in Leeds.

Used Motor Oil

A tank for used motor oil at a car accessory supermarket proved popular for several years but was clearly not the correct container. Shell UK have recently sited a smart igloo type container at a busy filling station in Leeds as part of a national pilot. The level of usage is growing week by week. This appears to be the ideal container on the ideal site.

Conclusions

On the face of it, a very successful green initiative and one that Leeds can be proud of. We have piloted can collection, plastic bottle collection, the use of igloos for paper, the supermarket based multi-material centre and we can still boast the largest collection scheme in the UK.

In reality, we have only scraped the surface in terms of reducing waste. SWAP collects only 3% of the City's domestic waste which, although useful, cannot be claimed to have any real impact on future waste disposal.

The real value of the last twelve years' experiments lies in

the knowledge accumulated for use both by ourselves and others throughout the UK who have followed our lead.

The SWAP Scheme in the Future

The aim is to reduce the City's waste by 20% by the year 2000. The climate for waste recycling has improved beyond recognition since 1977 and the level of public and political support for the project has increased dramatically over the last twelve months.

The existing paper and glass schemes are to be expanded. New projects are soon to be introduced for plastic bottles, drink cans and other materials wherever possible.

Existing and new main sites are being developed with modern containers, clear signs and landscaping to provide attractive and easily maintained recycling centres.

A Recycling Development Officer has recently been appointed with the aid of an Urban Development Grant. This officer's role is to develop new initiatives and to improve the scheme's image.

The National Scheme

Amongst the many environmental issues facing this planet, the creation of waste and how we handle what we create is a fundamental one. It is not simply the waste of resources which should concern us but the fact that our disposal methods pollute both our water and atmosphere and contribute to the 'greenhouse' effect through the production of methane and carbon dioxide. Consider also that, unlike most other issues, the solution depends on individual participation and the subject becomes central to our approach to the future of the planet. It also begs the question as to whether we are capable of sorting out the many complex issues involved in returning to a state of equilibrium with our environment if we cannot get to grips with what to do with our rubbish!

It is not within the brief of this paper to detail the need for the development of a national framework within which schemes such as SWAP can flourish. It is clear, however, that pressure to reduce waste is building up from within the EEC which will not only lead to a deeper involvement of the packaging and retailing industries but also of local authorities.

We need recyclable or returnable packaging. We need recycling centre buildings at shopping centres and amenity sites. We need to develop the reclamation industries. These and many other factors should be examined and built into a strategy for the future.

Finally, from the District Council's viewpoint, I believe that we need to go full circle. The SWAP scheme resulted

from a decision not to collect waste paper door-to-door on economic grounds. If we are really to tackle the problem of waste can we afford <u>not</u> to collect separated recyclable waste from households?

ENVIRONMENTAL AUDIT THE KIRKLEES STATE OF THE ENVIRONMENT REPORT

By

Les Reason
Kirklees Metropolitan Borough Council

In January of this year Kirklees Metropolitan Council and Friends of the Earth jointly launched the Kirklees State of the Environment Report to an audience of 150 people representing various environmental groups and organisations. The Report was the culmination of six months of intensive effort by Dr Tim Elkin who was the author of this detailed examination of the characteristics and performance of the physical environment of the metropolitan district of Kirklees. Since that time it has become the role model for many of the environmental audits which local authorities have been undertaking prior to the development of "green" policies and strategies.

This unique collaboration between a large local authority and an international environment pressure group arose out of strange circumstances. In early 1987 the Council was approached by Friends of the Earth to participate in an embryonic campaign "Cities for People". The basic aims of this campaign were for local authorities and Friends of the Earth to collaborate in research, and to promote and exchange information on environmental issues. In the event the campaign failed to materialise in the manner envisaged due to insufficient interest by local authorities. To compensate Kirklees, a number of alternative propositions were suggested, including eventually the offer to produce a State of the Environment Report. This was eventually accepted. The Report itself was jointly financed by the Council and Friends of the Earth and cost a total of £6,500 plus overheads. To enable it to be undertaken a researcher - Dr Tim Elkin - was contracted for a six month period to work out of the Authority's offices in Huddersfield. Tim Elkin is a town planner who had undertaken a not dissimilar assessment of the environment in Waterloo, Ontario, Canada. It was this knowledge and experience which enabled his task in Kirklees to be undertaken within the six month period set for the study.

Obviously, it was recognised that with the short period of time available it was not possible to pursue innovative or primary research. As a result much of the investigation was based upon the analysis and interpretation of published information. Inevitably more data would have been useful, particularly at the very local level, but this was not

available and could not be gained in the time. By being the first in the field of producing such reports there was the significant benefit of people being willing to provide advice and support in a very positive manner. It is by no means certain that this commitment could ever be repeated not least because of the changes in legislation and external working arrangements. The promotion of the State of the Environment Report has benefitted the Authority in several ways:

a. it was the first such report to be produced and it was published when the public's concern of environmental issues was increasing rapidly. Thus the Council has been at the forefront of the political green agenda;

b. by virtue of the co-operation with Friends of the Earth there has been additional publicity and credibility, together with a greater understanding of each other's needs, aspirations and functions;

c. the availability and skill of Dr Tim Elkin enabled the Report to encompass a wide range of topics which may not have been possible to investigate in any other way.

ORGANISATION AND METHOD

From its concept it was decided that the Report should be produced slightly outside the local authority's normal working system. By so doing it would enable criticism/comment to be made of the actions and priorities of the Council, if this was appropriate. Equally, as it was to be produced in a relatively short time, it had to try to avoid being weighed down by reports to committee etc. In the event the project was managed by a Steering Group consisting of representatives of local industry, the Huddersfield Polytechnic, Friends of the Earth (national and local group) and officers of relevant Council departments. Although there was no significant political involvement in the production of the report it did have the overt support of each of the three political parties which composed the "hung council" of the time. This form of support is well worth having as is the fact that any committee involvement should be non-department led, such as Policy and Resources, to enable better corporate working to take place.

The Steering Group met on four separate occasions. Its main task was to oversee the work and give support and direction as and when necessary. It provided the three basic objectives which the Report aimed to satisfy, namely,

a. to provide an understanding of the environment of Kirklees and its inter-relationship with social and economic activity;

b. to increase public access to environmental information and raise awareness of and concern for the environment of Kirklees;

c. to provide a baseline of environmental conditions against which future change can be measured.

A dilemma which the Steering Group had to face very early on, was the question of whether or not to include any recommendations. The Report is essentially the collation and interpretation of information, not a policy statement for the environment. Furthermore a local authority and an international environmental pressure group have different outlooks and priorities. It would not be easy to come up with a large number of recommendations whose words were meaningful and acceptable to both parties. In the event, a small number of fairly simplistic and acceptable recommendations were produced covering, though not comprehensively, a number of topics.

To satisfy the objectives a non-scientific approach was adopted which avoided the use of scientific language which it was felt could affect people's interest. The process also needed to be capable of being repeated by other parties or by the Council itself at some future date. As a result a simple A, B, C model was developed.

A refers to the Abiotic System covering topics such as water and air pollution, waste disposal energy use etc.

B is the Biotic System covering wildlife conservation, agriculture, forestry etc.

C is the Cultural System including transport, forestry,

In all 11 topics were investigated. For each topic area a standard process was followed which incorporated an examination of the institutional arrangements including legislation, standard areas of responsibility, trends - what is happening and why - and finally recommendations.

RESULTS

Two of the questions people ask about the document are "how does the environment of Kirklees compare with other local authority areas?", "Did the Report highlight any major problems of which the Authority was not already aware?". The answers are don't know and no. Don't know is the result of being first in the field: there is nothing with which to compare Kirklees; and no because using existing published information it was unlikely that something of major importance would be missed. It does clearly show the relative intensity of the various issues in a coherent and corporate manner.

In a document which contains approximately 190 pages this paper can do little more than summarise the main findings of the topics investigated and to look at, albeit briefly, the inter-relationships between different problems.

AIR QUALITY

There are several gaps in knowledge about the air quality of Kirklees. The situation regarding trace pollutants is generally unknown for these are monitored by the Inspectorate of Pollution and are not publicly available. A number of traditional pollutants such as nitrogen dioxide and carbon monoxide are not regularly monitored by the Council itself with the result that little is known about the long term trends.

Smoke Control Orders currently cover about 68.5% of all households in Kirklees with a concentration of coverage in the main urban areas of Huddersfield and the heavy woollen area of Dewsbury Batley.

Information of amounts of acid rain for Kirklees indicates clearly that it receives some of the highest levels in Britain. Although there is no direct evidence of its effects on the local ecology, the research undertaken nationally and internationally does suggest that the wildlife of the area is at risk.

WATER POLLUTION

Of the rivers which flow through Kirklees 28km (31% of total) are of poor or very poor quality with 15km classed as grossly polluted. It is only in the Pennine headquarters of these rivers that fish can survive without disease, blisters and scabs. Little improvement has occurred in recent years and it will not improve until Yorkshire Water or its successor controls more effectively the incidents of pollution and invests substantial sums in new or improved sewage treatment works. Many of the water pollutants exceed by a considerable margin the levels set by EEC standards.

The area's drinking water supplies have a bacteriological quality within 97.9% of the standards set, but this is a deterioration of 1.4% over the last 10 years. But the major problem is water discolouration due to the presence of peat particles. To remove these Yorkshire Water adds Aluminium Sulphate. Not all this is precipitated out with the result that there are reservoirs in the Pennines which supply water with an aluminium content exceeding the Directive amount of 0.2mg/litre between 50% and 80% of the time.

WASTE

There would initially be many immediate environmental problems being created through the operation of waste disposal sites. However there are the inevitable issues related to methane and its seepage which are currently being monitored in existing and closed sites.

The Authority is pursuing a policy of better recycling of materials such as paper and glass. It therefore needs to gain the support of the four districts which form the West

Yorkshire Waste Management Service to be more effective in this area and so reduce the need for landfill disposal.

NOISE

The general noise environment of Kirklees is unknown as no overall monitoring is undertaken. Issues are dealt with on a complaint basis so no long term trends are known.

ENERGY

Like many authorities Kirklees operates an Energy Efficiency Unit which attempts to minimise use of all forms of energy in the civic and educational buildings. Only recently has this been extended to its housing stock where heat insulation (walls and roofs) measures form part of the improvement schemes.

AGRICULTURE

Monitoring in a systematic or ad hoc manner of the agricultural trends and its effects on the landscape has not been pursued. Much of the rural areas are defined within the Less Favoured Areas and contain many part-time farmers. The Ministry of Agriculture, Fisheries and Food does not have or publish reliable data on part-time agriculture thus providing no help for monitoring. Visual appraisals do suggest that a gradual change in type of activity is occurring as subsidies change, urban pressures occur and in the Pennine foothills the problems of "lotting" reduces the viability of part-time farming. The only systematic and scientific monitoring which is being pursued is in the North Peak Environment Sensitive Area which is the south western part of the District and mainly in the Peak District National Park. However, this will take at least five years before any results are available.

WILDLIFE

At the time of the Report's publication there was little systematic appreciation of the wildlife priorities of Kirklees. Since that date a strategy has been produced which contains a large number of policies for adoption relative to the main environmental components.

FORESTRY

Tree cover within the District amounts to a little over 3% of the area. Much of it is in private ownership and if managed at all it is generally poor in quality. The report highlights clearly the need for greater co-ordination between private owners and the various departments of the local authority to improve quality and quantity of tree cover.

TRANSPORT

The main problem of traffic and its growth is its effect on the environment through noise, air pollution and visual intrusion. Political problems exist in seeking designation of Heavy Goods Vehicle routes. One startling finding of the Report is the low use of cycles as a means of people getting to work (less than 1% of all trips). But then much of the District is hilly so it will not be an easy journey anyway.

REACTION AND ACTION

The Report was published in January 1989 and after its launch at a seminar it was presented to the various committees of the Council. Rather than merely approving it and let it gather dust like so many reports the Council established a small group of officers and members to examine in detail the actions and activities necessary to progress improvements in the environment of Kirklees. This has become the model for other such groups to operate outside the normal formal structure throughout the Council.

Like so many authorities recently the various Committees have gone through the trauma of re-structure and name changes. In the case of the content of the State of the Environment Report there has been the establishment of an Environment Committee whose terms of reference cover all things "green". It has also been granted an additional £40,000 capital budget allocation to act as "seed" money to help finance new environmental projects.

The Authority already had various purchasing policies related to not using CFC products and non-sustainable timber goods and these are being extended. In pursuit of such action, legal opinion is awaited to determine the legal position as to whether or not such restrictions conflict with Section 17 of the Local Government Act 1988, ie "non-commercial considerations" in any public contract.

The report has been instrumental in many ways in affecting the working of the Council, its priorities and actions, some of which will take some time to implement. Efforts are being made through the Working Group to develop an Environmental Strategy or Charter. Inevitably the production and endorsement of a wide ranging policy document is taking some months to produce, and it clearly highlights the needs of corporate work and action to cover the range of topics and responsibilities of a local authority.

The list of current actions which the Authority is pursuing is quite extensive but perhaps two specific ones are worth noting. Much is made in the Report of the need to recycle waste material both as a social and economic benefit. Kirklees is a waste collector and generator, disposal is a joint arrangement with the other four districts of West Yorkshire through the Waste Management Service. In producing its waste disposal plan the Council will

pressurise the Service to seek more recycling in order to reduce land required for tipping and to gain some additional income. Kirklees itself would have to alter its collection system to enable separation of materials. At present it provides bottle banks and waste paper containers and shortly aluminium banks. These are being promoted by the recently appointed Recycling Officer. It is her responsibility to pursue a range of recycling issues with vigour including re-using material generated by the Authority itself not least of which is paper.

A second and perhaps more interesting example of use of the report has been by the Directorate of Social Services. As probably the least likely Directorate to be concerned with environmental matters it has become the most aware in its actions. Within the Directorate there is a complex web of communication groups and in each such group an individual is identified who receives and communicates information on environmental matters from and to all parts of the organisation including clients. These actions range from matters such as consumer advice, to use of energy, to purchase and use of goods. An illustration of the latter is the withdrawal from use of aluminium pans in the preparation of food for old people in order to reduce the possibility of senile dementia.

CONCLUSIONS

The State of the Environment is not a document which outlines the policies and proposals which the Authority in partnership should follow. It is the beginning. It has set a framework of understanding and awareness amongst offices and elected representatives which was not there before. Whether as a result of raising the political profile of "green" it would have happened anyway is an unknown.

To collaborate with a major pressure group has been of considerable benefit to each party. From the Authority's point of view there has been better joint working, an appreciation of the powers and statutes which the Council has and has not relative to the environment and how little District - wide or point - specific data it currently has. This is to be rectified within the normal finance and manpower constraints affecting all local government. I cannot claim to know what benefits Friends of the Earth have received. I suspect much publicity (like Kirklees), a better appreciation of the functions and responsibility of a local authority, and certainly it influenced the recently produced "Environmental Charter for Local Government". Neither party will claim that the State of the Environment Report is more than the start of a long process of change and hopefully improvement.

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CONTENTS

ACID RAIN — CAUSE AND CONSEQUENCE

By

Sir John Mason CB, DSc, FRS

This paper first appeared in March 1990 in "Weather", published by the Royal Meteorological Society. It covers many of the issues discussed by Sir John in his Presidential Address to the Annual Conference of the NSCA.

"Acid Rain" is a short-hand term that covers a set of highly complex and controversial environmental problems. It is a subject in which emotive and political judgements tend to obscure the underlying scientific issues which are fairly easily stated but poorly understood. This review deals solely with the scientific problems, attempts to establish the facts, describes the present state of knowledge and understanding and discusses what research is needed to provide a firm basis for remedial action.

Although the term *acid rain* is commonly used to describe all acid deposition from the atmosphere that may cause damage to trees, vegetation, fisheries, buildings, etc., in fact rain (and snow) brings down only about one-third of the total acid over the UK, two-thirds being deposited in the dry state as gases and small particles. But wet or dry, there is little doubt that acid deposition from the atmosphere poses an ecological threat, especially to aquatic life in streams and lakes on hard rocks and thin soils in southern Scandinavia and in some parts of Scotland and North America. It may also contribute to the serious tree damage reported from Germany and other continental countries, but to what extent it is responsible is by no means clear. In neither case are we likely to resolve the conflicting evidence and opinions and find convincing answers and effective solutions unless we approach the problems in a rational, scientific manner.

The Problem and the Programme

The problem becomes apparent when the damage exceeds a certain level generally accepted as normal and then spreads or intensifies rapidly as the natural control mechanisms fail to cope. It is then necessary to determine, by careful observation and measurement, the nature, extent and intensity of the damage, the rates of change and whether these are gradual, episodic or step-changes and to compare these with past records if they exist. The next step is to correlate the damage symptoms with internal or external events judged to be likely causes or contributors before invoking more imaginative or fashionable hypotheses.

In most complex ecosystems there is unlikely to be a single well defined cause but rather a combination of several contributory factors, some acting synergistically, others in opposition, so that it becomes necessary to identify and study the controlling processes and mechanisms in what is usually a complex, interactive, multifactorial system. This will often involve a combination of observational and experimental investigations in the field, laboratory and theoretical studies of basic processes, and simulation of the total system or parts thereof by means of mathematical models. Whatever the approach, progress will depend largely on ascertaining the facts from good, reliable observations and measurements.

It is in this spirit that the Royal Society, the Norwegian Academy of Science and Letters and the Royal Swedish Academy of Science, with funds provided equally by the British Central Electricity Generating Board and the British National Coal Board, established in 1984 a major research programme lasting for five years, to study many aspects of the acidification of surface waters in the three countries. This involves more than 30 research groups from a wide variety of disciplines and institutions working in a closely integrated and coordinated overall programme, the scope of which is illustrated in Figure 1. A complete coverage of the relevant scientific problems includes studies of the transport and chemical transformations of emitted pollutants in the atmosphere; the wet and dry deposition of the resulting acids; the acidity and chemical composition of the rain and snow; modification of the chemistry of the rainwater as it percolates through and interacts with the soil and rocks; and the toxic effects of the modified water chemistry on aquatic biota in streams and lakes.

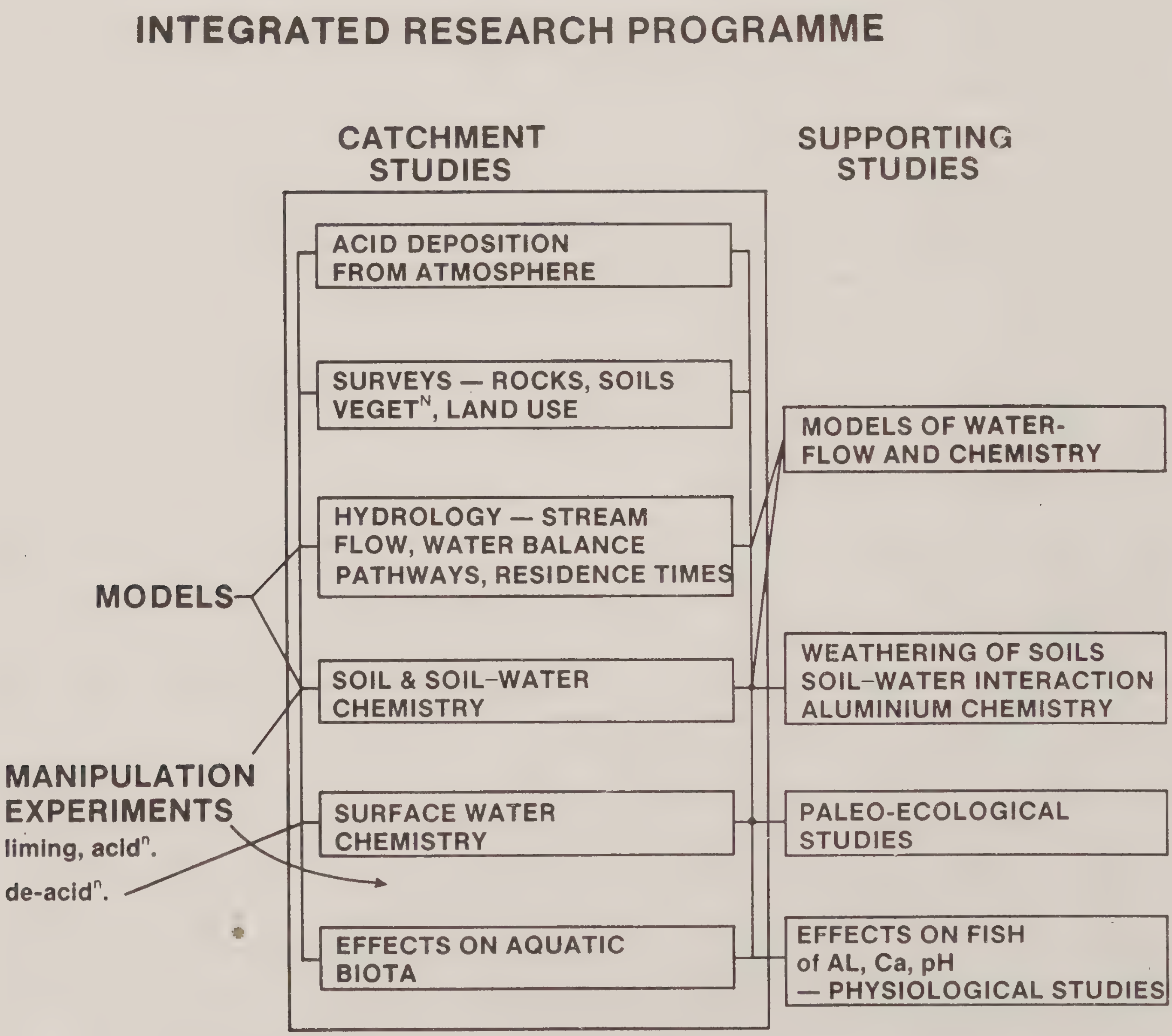

Fig. 1 The scope and organisation of the integrated research programme of the Royal Society and the Scandinavian Academies

The Atmospheric Chemistry of Acid Depositions

Understanding the problem of acid deposition requires knowledge of the distribution in space and time of the major acidifying pollutants, SO_2, NOx and HCl; their chemical transformation in the atmosphere; and their removal by deposition on the Earth's surface, either directly in gaseous or particulate form (dry deposition), or after incorporation into cloud and raindrops (wet deposition). The chemical reactions involved in both the gaseous and liquid phases are complex and incompletely understood but are the subject of much active research involving the measurement of the concentrations and conversion rates of chemical species in the atmosphere, laboratory measurements of key reaction rates, and the use of complex models to simulate the many simultaneous, interactive, chemical reactions.

Emissions

The total annual emissions of SO_2 and NOx in the UK (expressed in millions of tonnes of S or N), together with figures for Europe, are shown in Table 1.

Table 1. Annual emissions of S and N (Mt/yr) for United Kingdom and Europe

Pollutant	1900	1950	1960	1970	1980	1984	1987
United Kingdom SO_2	1.4	2.3	2.8	3.0	2.33	1.77	1.93
NOx	0.21	0.30	0.41	0.50	0.54	0.63	0.74
Europe (excluding USSR)							
SO_2	—	10.0	—	18.4	20.0	—	—

The United Kingdom contributes <2 per cent to the total input of sulphur into the global atmosphere and <10 per cent of the man-made sulphur produced in western Europe. The UK emissions of SO_2, 60 per cent of which come from power stations and about 30 per cent from industrial plants such as refineries, have fallen by 35 per cent since 1974, but the emissions of NOx, about 45 per cent of which come from power stations and 30 per cent from motor vehicles, continue to rise. The total deposition of sulphur on the UK in 1980 was 0.7 million tons, about 30 per cent of the emissions, two thirds being dry deposition and one third in precipitation. About 80 per cent of this total deposition was estimated to come from UK sources. The rain-bearing westerly winds ensure that the UK emissions make a significant, but not predominant, contribution to total acid deposition in Sweden and Norway, the contributions being about 5 per cent and 10 per cent respectively, but uncertain by a factor or two.

Chemical Transformations

Once emitted into the atmosphere, the pollutants are carried and dispersed by atmospheric motions, the plume from a point source, such as a power station, spreading out into an expanding cone which meanders with fluctuations in the wind. The plume is largely confined to within the atmospheric boundary layer, in the lowest 1-2 km, unless it is carried up into cloud systems. A good deal of the acid deposition reaches the ground in dry (gaseous or particulate) form close to the source but the rest may travel

for hundreds of kilometres during which time the gases SO_2 and NOx are oxidised and converted into lowly volatile products such as sulphuric and nitric acid, either in gas phase reactions or, more effectively, by becoming captured by cloud and raindrops (where the chemical transformations proceed much more rapidly in the liquid phase) and are eventually brought to the ground in rain or snow.

Although acid production proceeds much more rapidly in the liquid phase, clouds and rain are present only a small fraction of the time, so gaseous transformations and deposition are important and account for about two-thirds of the total acid deposition in the UK and about one-third in Norway.

The rates of conversions of SO_2 and NOx to H_2SO_4 and HNO_3 are determined by measurements from the Hercules flying laboratory of the UK Meteorological Office. This flying laboratory can locate and follow a chemically marked plume from a particular power station; sample the air inside and outside the plume as it crosses the North Sea; analyse it for all the relevant chemical species (for example, SO_2, NO, NO_2, oxidising agents such as O_3, H_2O_2, hydrocarbons, and aerosols); and collect cloud and rainwater and analyse these for pH, all main ionic species, H_2O_2 and other chemicals. In order to explain the observed conversion rates of SO_2 and NO into acids it is necessary to invoke photochemical reactions involving highly reactive oxidising agents such as O_3 and O* leading to the formation of the important radical OH which is unreactive to oxygen and therefore relatively stable. Some of the more important chemical reactions may be summarised as follows:

Gaseous reactions in a dry atmosphere

- Sulphuric acid

$$SO_2 + OH + M \rightarrow HSO_3 + M \quad \text{(M is a third inactive molecule)}$$
$$HSO_3 + O_2 \rightarrow HSO_5$$
$$HSO_5 + H_2O \rightarrow H_2SO_4 + HO_2$$

with HO* resulting from

$$O_3 + h\nu \rightarrow O^* + O_2$$
$$O^* + H_2O \rightarrow 2HO$$

The aircraft measurements indicate a conversion rate of about 16 per cent per day in summer, when solar ultra-violet radiation permits ready photolysis of ozone, but this is reduced to about 3 per cent per day in winter.

- Nitric Acid

$$NO + O_3 \rightarrow NO_2 + O_2 \quad \text{(fast)}$$
$$NO_2 + OH + M \rightarrow HNO_3 + M$$

The conversion rate is about 20 per cent per hour in summer and about 3 per cent per hour in winter, so conversion would be complete in a 24-hour traverse of the plume across the North Sea in summer.

Liquid phase reactions in clouds and rain

- Sulphuric acid

$$2SO_2 + 2H_2O \rightarrow SO_3^{2-} + HSO_3^- + 3H^+$$
$$HSO_3^- + H_2O_2 \rightarrow HSO_4^- + H_2O$$

with H_2O_2 resulting from

$$HO_2 + HO_2 \rightarrow H_2O_2 + O_2$$

and HO_2 from gaseous reactions such as:

$$OH + CO \rightarrow CO_2 + H$$
$$H + O_2 + M \rightarrow HO_2 + M$$

The conversion rates are very fast, almost 100 per cent per hour in summer and 20 per cent per hour in winter in the presence of sufficient concentrations of the oxidants O_3, OH, HO_2, H_2O_2 and hydrocarbons which may be the limiting factor.

- Nitric acid

$$NO_2 + NO_3 + M \rightarrow N_2O_5 + M$$
$$N_2O_5 + H_2O\ (liq) \rightarrow 2HNO_3$$

This reaction is believed to be rapid but conversion rates have not been established.

Both the aircraft measurements and the photochemical models indicate that the rates of production of acids from the precursor gases are often limited by the availability of oxidising agents, hydrocarbons and solar ultra-violet radiation.

Acidity of Precipitation

In order to assess the effects of changes in the emissions of SO_2, NOx and hydrocarbons on the acidity of precipitation, it is necessary to have long term, reliable, accurate and representative measurements of pH, alkalinity, and concentrations of the main ionic species SO_4^{2-}, NO_3^-, HCO_3^-, etc., so that one may study their variations in space and with time. Unfortunately, rather few series of measurements satisfy these criteria. Accurate measurement of the pH of poorly buffered waters in the field is particularly difficult. In addition to analysis errors, changes may occur during collection, storage and transport, resulting in contamination, evaporation and biological activity of the sample. In our programme we have paid great attention to the improvement of analytical techniques and to their standardisation, intercomparison and intercalibration.

The pH of uncontaminated rainwater in equilibrium with atmosphere carbon dioxide is 5.6. Rain and snow almost everywhere, even in places as remote as Hawaii, the southern Indian Ocean and the polar regions, are more acidic than this, with average pH values of 5.0 or lower. This testifies to the ubiquity of acidic pollutants, the oceans being a major source of sulphur compounds resulting from biological activity and sea spray.

In 1978/80 the annual average pH of rain falling over the UK was almost everywhere between 4.5 and 4.2. The rain was more acidic on the eastern side of the country downwind of the main industrial conurbations, where the pH values are very similar to those encountered in southern Scandinavia.

Unfortunately, there are few reliable, long term records with which to assess recent trends in the acidity of precipitation. Perhaps the best record, maintained by the Freshwater Biological Association in Cumbria, shows that the annual mean pH remained sensibly constant at 4.4 between 1955 and 1975, during which period the total sulphate

deposition also remained roughly constant. This is consistent with the fact that the UK emissions of SO_2 and NOx combined, increased only slightly over this period and that 80 per cent of the total sulphur deposition in the UK comes from local sources. There is now some evidence, notably from measurements made by the Freshwater Fisheries Laboratory at Pitlochry, that the acidity of rainfall decreased (pH increased by about 0.2 unit) between 1979 and 1984, in conformity with the 34 per cent reduction in UK SO_2 emissions over that period. The sulphate concentration of rainwater collected in the Scottish Loch Ard catchment has halved since 1982. Moreover, between 1973 and 1986, the pH increased from 4.2 to 4.7, during which time UK emissions of SO_2 fell by 36 per cent.

In Europe there is also a dearth of reliable long term measurements, and some of the reported rather sharp increases in acidity of precipitation appear to have coincided with changes in measuring techniques. On balance, the evidence indicates that the acidity increased gradually from 1955 to 1970, during which time European emissions of SO_2 doubled, but there are indications of a slight reduction in the acidity and sulphate content of rainwater since 1980, concurrent with reduced emissions.

There is some evidence of a linear correlation between the sulphate content of rainwater and emissions of SO_2 based on average annual values, but the implications of this are complicated by the fact that, in many parts of the UK and southern Scandinavia, a large fraction of the total annual acidic deposition occurs on only a few days of heavy rainfall. In order to detect these high deposition episodes, which have a major ecological impact, frequent or continuous monitoring of the rainfall and its chemistry is necessary.

Moreover, the annual averages hide large seasonal variations in the acidic and sulphate content of UK rainfall, with the highest values occurring in summer when the emissions are least. This is probably a consequence of the fact that the conversion of SO_2 and NOx to acids is limited by the availability of oxidants such as O_3, OH, H_2O_2, which are produced by photolysis more effectively in the summer time.

The Acidification of Streams and Lakes

Measurements in many lakes in southern Scandinavia suggest that the pH has decreased by between 0.5 and 1.0 unit over recent decades. However, there is some doubt about the reliability of the measurements and the comparability of past and recent data. A reduction of one whole pH unit is unlikely to be due solely to increases in European emissions of SO_2 and NOx which only doubled between 1950 and 1970 and have increased only slightly since then. Part of the decrease in pH may have resulted from additional acidification processes at work in the catchment, or from the acid neutralising mechanisms in the soil not being able to keep pace with the acidic deposition (see next section). By contrast, biologically inactive lakes in Cumbria subject to acidic rainfall, with hard bedrocks and thin soils, very similar to those prevailing in southern Scandinavia, have shown no significant change in acidification over the last 50 years, during which period UK emissions of SO_2 doubled between 1930 and 1970 and have fallen by 35 per cent since then. In biologically active lakes, major changes of pH are caused by respiration, by photosynthesis and by decomposition of vegetation, and these often show strong diurnal and seasonal variations.

A chemical survey of some hundreds of lakes in southern Norway in the early 1970s revealed that 40 per cent of them had pH values of <5.5 and 16 per cent had pH values of <5.0. These, and some additional lakes, about 1000 in all, have recently been re-surveyed, using the same techniques, to determine whether there have been any significant changes in the intervening 12 years during which there have been marked reductions in emissions of SO_2, especially from the UK and Sweden. The results for lakes in areas of high acid deposition show a marked reduction in sulphate concentrations but a compensating increase in nitrates, so that, on average, the acidity (pH) has hardly changed. Lake Oxsjøn in Sweden, the sulphate concentration of which trebled between 1967 and 1977 while pH fell from 6.8 to 4.5, has shown signs of recovery since 1977, with the pH increasing to 4.9 and the sulphate concentration falling by one-third.

Evidence for the gradual acidification of lakes over longer periods comes from the analysis of acid sensitive species of diatoms from radioactively-dated lake sediments. The layers of sediment, laid down over several hundred years, are dated using radioactive lead isotopes and the diatoms found in the layers are correlated within similar populations found in the uppermost layers of lakes of known pH. It is thus possible to reconstruct a pH-age profile of the sediments. By this method it has been found that some lakes in Scotland which are situated on hard granite bedrock and thin soil and in areas of high deposition, have tended to become acid in recent decades. By contrast, little change in diatom populations has occurred in non-sensitive lakes in areas of high acid deposition, nor in sensitive lakes in areas of low deposition. Figure 2 shows that the pH of Round Loch remained sensibly constant at 5.5 between 1600 and 1850 but

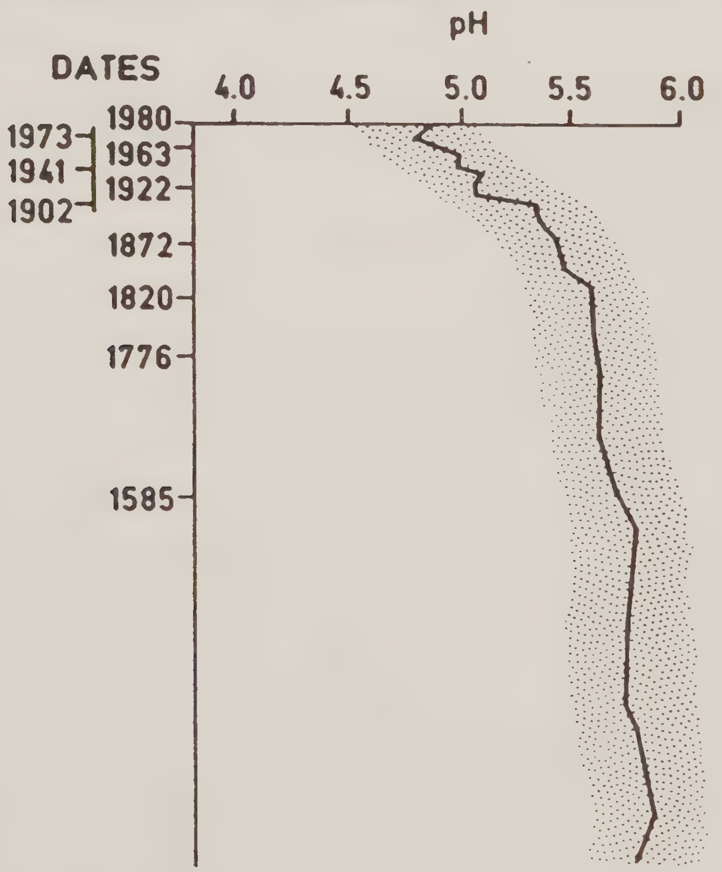

Fig. 2 The history of acidification of Round Loch of Glenhead (Galloway, Scotland) as deduced from diatom records (Courtesy of Dr. R.W. Battarbee)

thereafter steadily declined, with fluctuations, to 4.8 in 1973, the decline being particularly rapid since 1900, but this cannot be attributed to afforestation or changes of land use. A slight recovery to pH 4.9 is discernible between 1973 and 1980, associated perhaps with reduced emissions. Similar evidence for a slight recovery has been found in some other Scottish lochs in areas of high acid deposition.

A similar study on lakes near the south-western coast of Sweden, all afforested with hard bedrock and thin soil, also indicated a fall in pH from 6.5 to 4.5 since 1950. Diatom records from lakes in southern Norway also indicate a decrease in pH over recent decades, but a lake on the west coast with pH ~5 showed no significant change over 200 years.

The decreases in pH since the industrial revolution are likely to be due mainly to increased acidic deposition from the atmosphere, but more extensive measurements involving a wider variety of acid sensitive species are required to establish the historical trends and help resolve the apparent differences between the results for different locations.

Apart from the effects of man-made depositions, there appears to be a natural tendency for lakes to become more acidic with time due to the natural acid producing mechanisms in the soil (see next section) and a gradual decline of its neutralising capacity. These natural acidification processes are normally slow but may be accelerated by changes in land use. There is also evidence to suggest that the planting of coniferous forest accelerates acidification in areas of high deposition, due to the scavenging of acid aerosols and mist droplets by the forest canopy.

The general inference from these studies is that a large reduction in acidic emissions and depositions is likely to lead to a fairly rapid response in lake chemistry in some regions but, in others, particularly those where there are large accumulations of sulphate in the soil, recovery may be much slower.

The Importance of Hydrogeology and Soil Chemistry

There is undoubtedly a correlation between rainfall acidity and the occurrence of acid streams and lakes in susceptible areas. However, little of the water feeding streams and lakes arrives directly from the atmosphere; most does so only after flowing over the land surface or through soil. The details of the flow pathways and of the soil water interactions are not well known. Hydrological conditions and water flow pathways through the soil and rock determine the contact time of the acidified water with neutralising substances and thus the ultimate degree of water and soil acidification.

When the acidified rainwater reaches the ground some seeps through the soil but some, especially during continuous heavy rain, runs over the surface or through macropores and may enter the nearest stream with its chemical composition little changed. If, however, the rainwater penetrates the soil, its chemistry may be profoundly modified as the result of complex reactions with the underlying rocks, soil and vegetation involving many processes such as dissolution and weathering of minerals, cation exchange, accumulation and release of contaminants including humic and other organic acids.

If the rain or melt water of low pH passes through sandy soils poor in base minerals (e.g. Ca/Mg carbonates and bicarbonates) or passes over hard granitic rocks, then the rain/melt water will only be partially neutralised by cation exchange or weathering. The H^+ ions in the percolate will tend to be associated with SO_4^{2-} ions. In most catchments any NO_3^- ions which are present in the rain are largely taken up by the roots of growing plants and trees, thus immobilising the associated H^+ ions. (This may change if the increasing trend in NOx emissions continues.) The acidified water therefore passes through the soil with only a moderate pH change, and the soil itself undergoes little acidification.

In base-rich soils, H^+ ions in the acid water are either neutralised by bicarbonate ions during the dissolution of limestone or removed by exchange with cations such as CA^{2+}, Mg^{2+}, K^+, Na^+, Al^{3+} on the surfaces of mineral particles, or with cations on organic macromolecules in humus. H^+ ions may also be consumed in the soil by the reduction of nitrates and sulphates.

Chemical weathering of primary and secondary minerals are the ultimate means by which inputs of acids are counteracted. Chemical weathering transfers basic cations from primary minerals to the pool of exchangeable cations. A fraction of these are retained on the surfaces of soil particles and the remainder are lost in the run-off or percolate. H^+ ions from the acidic inputs are exchanged for the basic cations on the surfaces of the soil so that the acidity of the percolate decreases and that of the soil tends to increase. If the release of base cations by weathering keeps pace with the rate of increase of acid input, no soil acidification occurs. However, if the rates of chemical weathering are not increased sufficiently, soil acidification and subsequently water acidification results. Soil acidification partly caused by acid deposition seems to have occurred both in central Europe and in Scandinavia.

However, besides the deposition of acid substances from the atmosphere, several natural processes produce H^+ ions in the soil and reduce the pH of the percolating water. These include the production of carbonic acid by CO_2, the hydrolysis of minerals, the decomposition and nitrification of ammonium produced by bacterial decomposition of vegetation and by fertilisers, the oxidation of sulphur in dry soil, the action of organic acids from decaying humus, and the release of H^+ ions from the roots of plants and trees to compensate for the take up of Mg^{2+} and Ca^{2+} ions.

The acidity/alkalinity of the percolate is the net result of all these processes which act at different rates depending, in many cases, on the pH. In general, base-rich, weatherable soils tend to reduce the acidity of the percolate, whilst growing plants and trees, aided by fertilisers, tend to acidify both the soil and soil water. The deposition of acidifying components is also in general larger in a coniferous forest than in an unforested area. The rate of water acidification and the time lags involved probably depend very much on the amount of sulphate accumulated in the soil and the rate at which the SO_4^{2-} ions are released to accompany the H^+ ions in the percolate. After a long dry spell followed by heavy rain, or during snow melt, there is often a heavy transient release of mobile anions including NO_3^- which cannot all be taken up by plants and so is available for mobilising the H^+ ions, thereby increasing the acidity of the soil water.

In our programme we have investigated the above mentioned processes, chemical biological, and hydrogeological, that determine the quality of the surface waters and therefore the populations of fish and the organisms that provide their food. In each experimental catchment we have conducted detailed surveys of the geology, soils and vegetation and the mapping of the hydrogeological pathways of the water over and through the ground on its way to the streams and lakes. Of key importance is the modification of the chemistry of the water as it percolates through the soil by a variety of acidifying and neutralising processes. This has been studied by extraction and detailed chemical analysis of the percolate from different levels in the soil profile and relating these changes to the physical and chemical properties of the soils, measured weathering rates of the minerals, the rates of water flow (residence times) and the measured input/output budgets of the whole system. By making parallel studies in highly acidified, "clean" and intermediate catchments, it should be possible to deduce how the contributions and balance of the various processes and agencies are affected by changes in acid deposition.

Considerable effort has also been devoted to the development of hydrochemical models to help identify the key processes, design the field experiments and interpret the results.

Effects of Acidity and Aluminium Toxicity on Fishes

A decline in fisheries, or loss of certain species since the 1930s has been reported for many lakes in south Norway, south Sweden, parts of UK, Ontario and north-east USA. In view of the (not entirely convincing) evidence that the pH of some lakes has declined by as much as 1 whole unit and that low pH (<4.5) is known to be lethal to fish, especially in early life stages, it is reasonable to attribute decline in fish populations to an increase in acidity of surface waters. Unfortunately, well documented, long term records of fishery status and of water quality exist for only a relatively few lakes in Scandinavia and north-east America. For a sample of lakes in Europe and North America, over half of those with pH <5 were found to be fishless compared with about 1 in 7 of those with pH>5. This is illustrated in Figure 3 which also shows the importance of Ca in the water, higher concentrations of which tend to compensate for lower pH (higher acidity). An extensive survey of fishery status and water quality for some 700 lakes in south Norway failed to establish a direct relationship between fishery status and sulphate concentration because the calcium concentration and pH of the lakes, which are correlated with their altitude and distance from the coast, are dominant factors. More recently the toxic effects of aluminium leached from the soil and lake sediments have become firmly established. The toxicity of aluminium is a function of pH and is greatly moderated by the presence of calcium in solution.

In the pH range below 4.5 acidity *per se* may be a direct cause of mortality in fish depending on the species (salmon and trout are especially vulnerable), the age, size and genetic origin of the fish and the degree of acclimatisation. Acidity may also affect growth, fertility, egg mortality and recruitment of fry to the population.

Attempts to establish clear-cut relationships between water acidity and fishery status have been hampered by conflicting evidence between field observations, which are

usually concerned with long term and fluctuating acid exposures, and laboratory studies which almost always involve short term, constant exposures. It is important to investigate the response to both types of exposure, long term and episodic, since it is not clear which is the more important in the depletion of fish stocks. However, there is increasing evidence that large kills are produced by short episodes of high acidity, lasting only a few hours and associated with snow melt, or rain after a long dry spell. It appears that these occasional or seasonal pulses of acidity, often accompanied by high concentrations of aluminium are more lethal than sustained exposure to which the fish may adjust more easily.

The toxic effects of aluminium on fish are complex. They are very sensitive to pH and are strongly moderated by the presence of calcium or organic acids in the water. Only the inorganic monomeric aluminium, such as Al hydroxides and fluorides, appears toxic when its concentration exceeds 100 μg/l, which is a typical value for Scandinavian and North American rivers and lakes at pH<5. In the presence of organic acids derived from humus in the soil, the aluminium tends to form organic complexes, which are not toxic to fish.

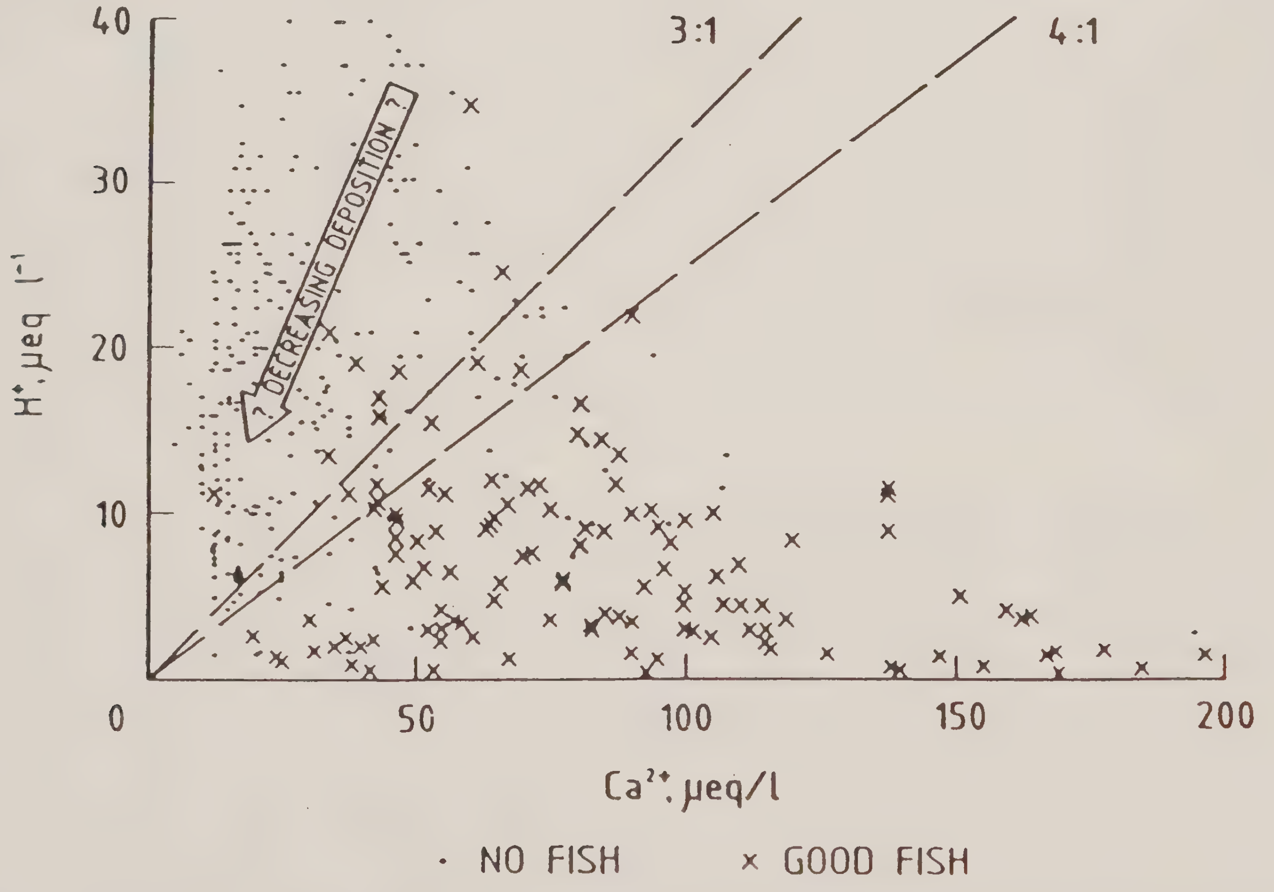

Fig. 3 The fishery status of a large number of Norwegian lakes in relation to their acidity (H^+ ion concentration) and the calcium content.

The apparently opposing effects of Al and Ca are far from being understood. Prolonged exposure to Al at pH≈5 causes severe damage to the gills and causes clogging by excess mucus. Freshwater fish continually lose salts in the large quantities of urine discharged to counteract the osmotic inflow of water. The salt loss is normally made good

by ion exchange across the gill surfaces, the magnitude and direction of the flux being determined by the distribution of electric charge across the gill membrane. In acid water of very low Ca content, this charge may be reversed so that the fish blood loses salt and becomes more acid. The adsorption of Al, particularly in the form of Al^{3+} and Al hydroxide ions, appears to damage the gills and further impair the ion-exchange process. However, if Ca is present, its ions are apparently preferentially adsorbed on the gill surfaces, where they block the absorption of Al ions and so reduce their impact.

The detailed mechanisms involved in the control, regulation and impairment of ion exchange across the gill membranes will have to be further elucidated before the relative toxicity of the various aluminium species and their moderation by calcium and organic complexation can be assessed. Such studies form an important part of our programme.

Concluding Remarks

I have attempted in this paper to demonstrate that acid rain is a complex problem spanning a wide range of disciplines and that there are considerable gaps in our present understanding of all the contributory mechanisms and their interactions. I believe that our comprehensive, strongly coordinated and focused research programme will have done much to increase our knowledge of recent changes in the chemistry and biology of surface waters, elucidate the underlying mechanisms, establish more accurately the contribution made by man-made emissions relative to natural acidification processes, and provide a firm scientific basis for effective remedial action.

The full results were presented and discussed in an international conference held at the Royal Society from 19-23 March 1990.

ACID RAIN - NEXT STEPS

A PAN-EUROPEAN PROBLEM

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The Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP) was initiated after the OECD-programme on long-range transport of air pollution. It is presently an activity under the UN Convention on Long-Range Transboundary Air Pollution (LRTAP) with its secretariat in ECE, Geneva. Under EMEP three different centres have been established. The Chemical Co-ordinating Centre (The Norwegian Institute for Air Research) is responsible for the co-ordination and quality assurance of chemical measurements. The two meteorological centres (Meteorological Synthesizing Centre - East [Institute of Applied Geophysics in Moscow] and West [The Norwegian Meteorological Institute in Oslo]) are responsible for making model calculations of transboundary transport of air pollutants. At MSC-W such calculations are made each year for oxidised sulphur and oxidised and reduced nitrogen. The EMEP centres report their results to the Steering Body of EMEP, which in turn reports to the Executive Body for the LRTAP-Convention. The activities in EMEP, and the model calculations of transboundary air pollutants in particular, are directed at supporting negotiations on emission control in working groups under the Convention.

"Acid rain" is a concept presently encompassing environmental effects caused by a change in the chemical composition of precipitation driven by anthropogenic activities. Precipitation in this context includes deposition onto the ground surface of gases, dry particles, and fog droplets. Hence, the term is much wider than only the traditional acidity of rain. It is now widely accepted that the total contents of anthropogenically produced ions in the environment is far more important than just the pH. Due to its large mobility in wet soils and the considerable amounts of it deposited, the sulphate ion is probably the most important contributor to damaging effects caused by acid rain. The acidity as measured by low pH values has damaging effects on a short term episodic basis, while the sulphate ion causes long term effects. A mobile sulphate ion has a potential to connect itself to base cations such as calcium and potassium in the soils and carry them with the ground water into rivers and lakes. Thus if the supply of sulphate ions is larger than the ability of the ground rocks to produce new base cations,

the soil's quality gradually deteriorates, and finally the situation may reach a state where toxic cations (eg aluminium hydroxy ions) are washed out from the ground.

In the OECD-programme and in the subsequent EMEP under UN, it is well documented by measurements and model calculations that the deposition of anthropogenic sulphate is a long-range transport problem. The sulphur pollution is mainly emitted into the atmosphere as sulphur dioxide when burning oil and coal containing sulphur. Depending on the oxidising capacity of the atmosphere, the sulphur is further oxidised to sulphate particles. This may take place in clear air or very efficiently inside clouds through heterogeneous processes. The average atmospheric residence time of sulphur dioxide is rather short (below 24 hours) due to efficient dry deposition and oxidation to sulphate. The sulphate, however, generally stays much longer in the atmosphere (residence time: 2-4 days) since it is a chemically stable end product with a very slow dry deposition. On the other hand, it is very efficiently scavenged by precipitation, and in actual cases the residence time of sulphate is determined by the probability of dry air parcels to become wet within a given time span. Therefore the possible transport distance of sulphate varies considerably with season as well as geographical position. These properties of long range transport of sulphate have been known for quite a long time (Rodhe and Grandell, 1972).

In recent years it has also become evident that nitrate has an increasing mobility in wet soils. Normally this ion is efficiently retained and taken up by plants as a nutrient. As the anthropogenic influence is increasing, some areas are over-fertilised and the nitrate ion becomes mobile with damaging effects similar to those created by sulphate. Furthermore, the extra supply of fertiliser provided in this way may partly contribute to problems connected with over-fertilisation, such as explosive growth of toxic algae in rivers, lakes and coastal waters. The emission of oxidised nitrogen into the atmosphere is generally in the form of nitrogen monoxide and nitrogen dioxide (NOx in short), and is to a large extent a consequence of the combustion processes in vehicle engines and industrial production. Atmospheric molecular nitrogen is oxidised to NOx with increasing efficiency as the pressure and temperature during the process increases. Car traffic is a major source of these emissions. The air-chemistry of oxidised nitrogen is more complex than for oxidised sulphur. In its primary phase oxidised nitrogen is slowly dry deposited, and hardly wet scavenged at all. The oxidation to nitrate can pass through nitric acid gas which is very efficiently dry and wet deposited, or go directly to particulate nitrate which is slowly dry deposited but efficiently removed by precipitation. In summary also the

deposition of nitrate is a long-range transport problem up to about 1000 km, but with a different pattern to that of sulphur. Figure 1 shows the deposition of total oxidised sulphur and oxidised nitrogen allocated to emissions in the United Kingdom in 1988. Since the deposition depends so heavily on the distribution and frequency of precipitation events, the deposition does not reflect a diffusive process where one expects a decrease with the square of distance. This is particularly evident for oxidised nitrogen because of the initial dry deposition. Areas with large precipitation, eg due to orography, receive larger amounts than expected because of the accumulative property of precipitation scavenging. Serious errors will be committed if in models one parameterises wet deposition in a way that does not reflect this accumulative nature of the process, such as, for example, assuming a constant depletion coefficient.

Being connected with transport to distances in the order of 1000 km, acid rain is a problem of a pan-European nature. An average-sized European country cannot solve a problem connected with acid rain within its borders without negotiating emission reductions with other European countries. Table 1 shows for a selection of countries how large a part of the country's own emissions is deposited inside its borders according to calculations for 1988 and 1989. As can be seen, this part is dependent on the size of the country, but for average-sized countries about 20-30% of the sulphur and 10-15% of the nitrogen is deposited inside their borders. As can be seen, there are significant variations between the years. The countries' contribution to another area such as Norway or Sweden or the whole domain of calculation, depends very much on geographical properties. The United Kingdom is situated on the upwind side of continental Europe in relation to predominant wind directions which are westerly. As one moves eastwards from central Europe countries are downwind of the central part of the domain, and an increasing portion of the emissions are simply transported to other areas outside. This is particularly true for emissions in the European part of USSR, but the geometrical effect is also evident for Polish emissions. It can also be seen that a relatively larger part of oxidised nitrogen is connected with transboundary transport than sulphur, but for depositions to the total domain, the differences are not so evident.

Under the framework of the LRTAP-Convention negotiations are presently taking place in the Working Group on Abatement Strategies on how to develop control strategies for emissions leading to acid deposition. The present approach is to map the critical loads in Europe. The critical load in an area is the largest deposition amount a recipient can sustain without damaging effects. The critical load, eg for sulphate,

depends on the buffer capacity in the different catchments for precipitation, which in turn is a function of the thickness and acidity of soils and rocks in the ground. Maps of critical loads will show large regional variations. The Task Force on Mapping, which reports its activities to the Working Groups on Effects, is in the process of compiling such maps for Europe. By subtraction of the numbers on the critical load map from those on the map of calculated depositions, one arrives at a so-called "exceedence map", which shows where damaging effects on the environment are to expected. Since the calculations allocate depositions to known emission sources in the different countries, the excess is also country allocated, and one can produce optional control strategies to reduce or remove it. In evaluating these options one can take into account economic and technical feasibility through cost functions for transport, energy and industrial production. The task Force on Integrated Assessment Modelling is presently evaluating such methods for the Working Group on Abatement Strategies. In practice it is very difficult to remove all excess depositions relative to critical loads. For some areas, politically agreed target loads can be used instead. Another possible approach is to use the current best available control technology.

Table 2 shows the deposition of sulphur in three EMEP grid-squares allocated to emissions in countries. According to a critical load map made by Chadwick and Kuylenstierna (1989) and further compiled to the EMEP grid (Derwent, 1990), by letting the most sensitive area inside a grid-square define its critical load, the critical load in point 1 on the border between Czechoslovakia, GDR and Poland is 0.32 - 0.64 grammes S per meter squared, whilst in point 2 in central England it is 0.64 - 1.28 $g(S)/m^2$, and in point 3 in southern Norway it is lower than 0.32 $g(S)/m^2$.

It is important to be aware of the fact that the different countries' contributions to depositions in given grid points are changing considerably from year to year because of varying meteorological conditions. Figure 2, taken from Eliassen et al (1990) shows how the calculated deposition of sulphur would have varied from year to year in the eight-year period 1979-1987 if emissions were as in 1980. Only the interannual meteorological variability causes these variations. In some grid-points the variations amount to as much as a factor ten. As a consequence one cannot base control strategies upon calculations for one year only. Since such strategies are supposed to work for future years, it is of little value in this context to focus on unit areas in which critical loads are mapped smaller in size than an EMEP grid-square, even if the geology should suggest so. Likewise, it is of limited

value to attribute depositions to emission areas significantly smaller than an average-sized European country.

Calculations and measurements of sulphur dioxide and particulate sulphate have been made for EMEP for more than ten years. These data constitute a large part of a long-established series which can be utilised to assess the reported emission reductions from the different countries. By controlling the meteorological input to the calculations independent of emission data, trends in concentration levels due to emission changes can be estimated. Such a study has been made by Mylona (1989). From 1980 to 1986 the reported emissions (by November 1988) show an overall reduction in Europe of 16%. Filtering out variations due to meteorology reveals a corresponding reduction in the concentration levels of SO2 at about 19%, and for sulphate about 16%. Even though there are regional differences, this can be taken as a confirmation of the reported emission reductions.

References

Chadwick, M. and Kuylenstierna, J. (1989) The relative sensitivity of ecosystems to the indirect effects of acidic depositions. Beijer Institute Centre for Resources Assessment and Management, University of York, UK.

Derwent, R. G. (1990) Optimal strategies for sulphur emission control in Europe. Modelling and Assessment Group, Environmental and Medical Sciences Division, Harwell Laboratory, Oxfordshire, UK.

Eliassen, A., Saltbones, J. and Sandnes, H. (1990) Some properties of deposition patterns of nitrogen and sulphur and their implications for European abatement strategies. EMEP/MSC-W Note 1/90, The Norwegian Meteorological Institute, Oslo, Norway.

Mylona, S. N. (1989) Detection of sulphur emission reductions in Europe during the period 1979-1986. EMEP/MSC-W Report 1/89, The Norwegian Meteorological Institute, Oslo, Norway.

OECD (1979) The OECD programme on long range transport of air pollutants. Measurements and findings. 2nd edition. Organisation for Economic Co-operation and Development, Paris.

Rodhe, H. and Grandell, J. (1972) On the removal time of aerosol particles from the atmosphere by precipitation scavenging. Tellus, 25,442-454.

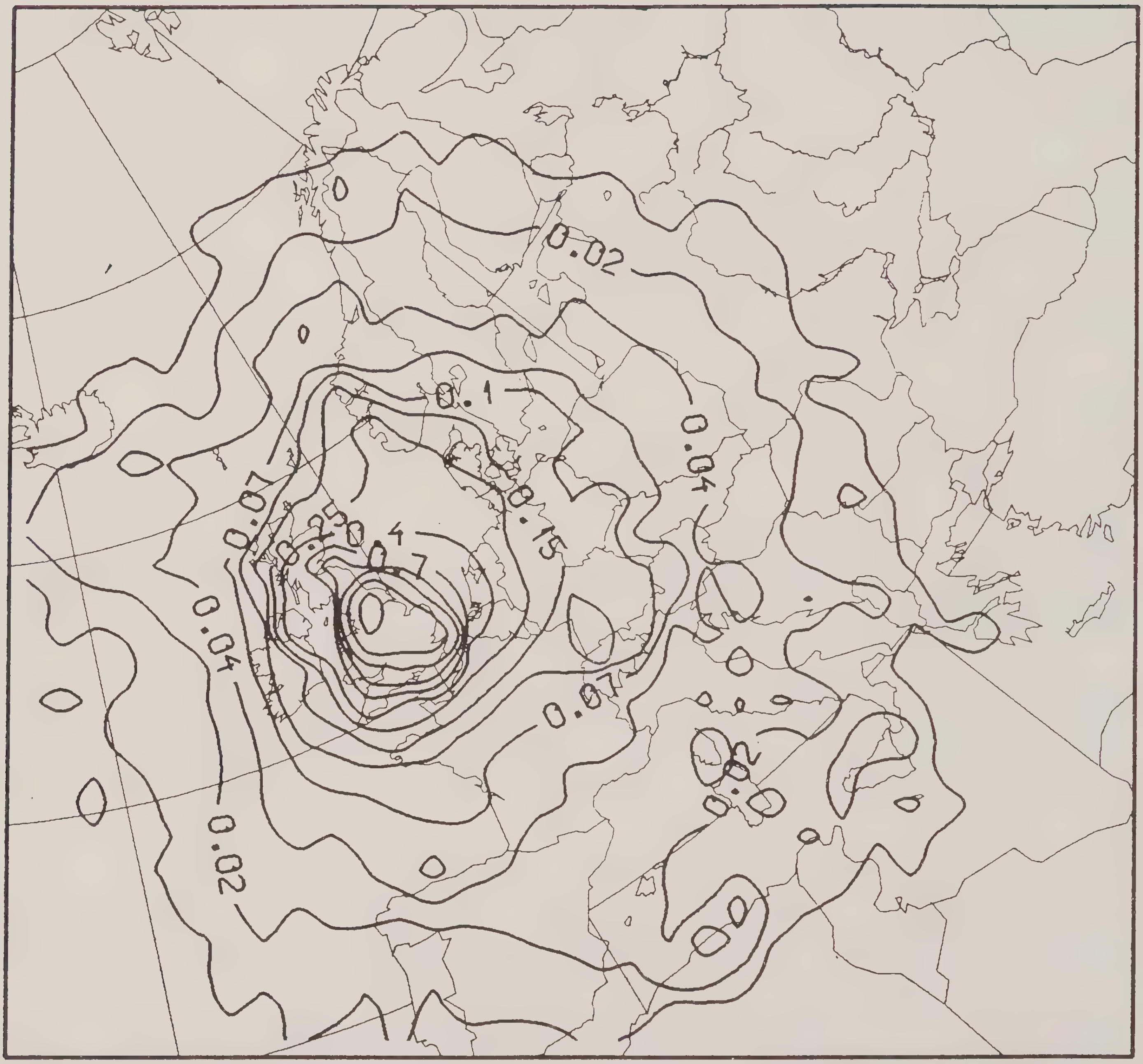

Figure 1 a) Deposition of oxidised sulphur allocated to emissions in United Kingdom. Calculations for 1988. Isolines for 0.01, 0.02, 0.04, 0.07, 0.1, 0.15, 0.25, 0.4, 0.7, 1.0, 1.5, 2.5, 4.0, 7.0, 10.0 grammes per square meter as sulphur.

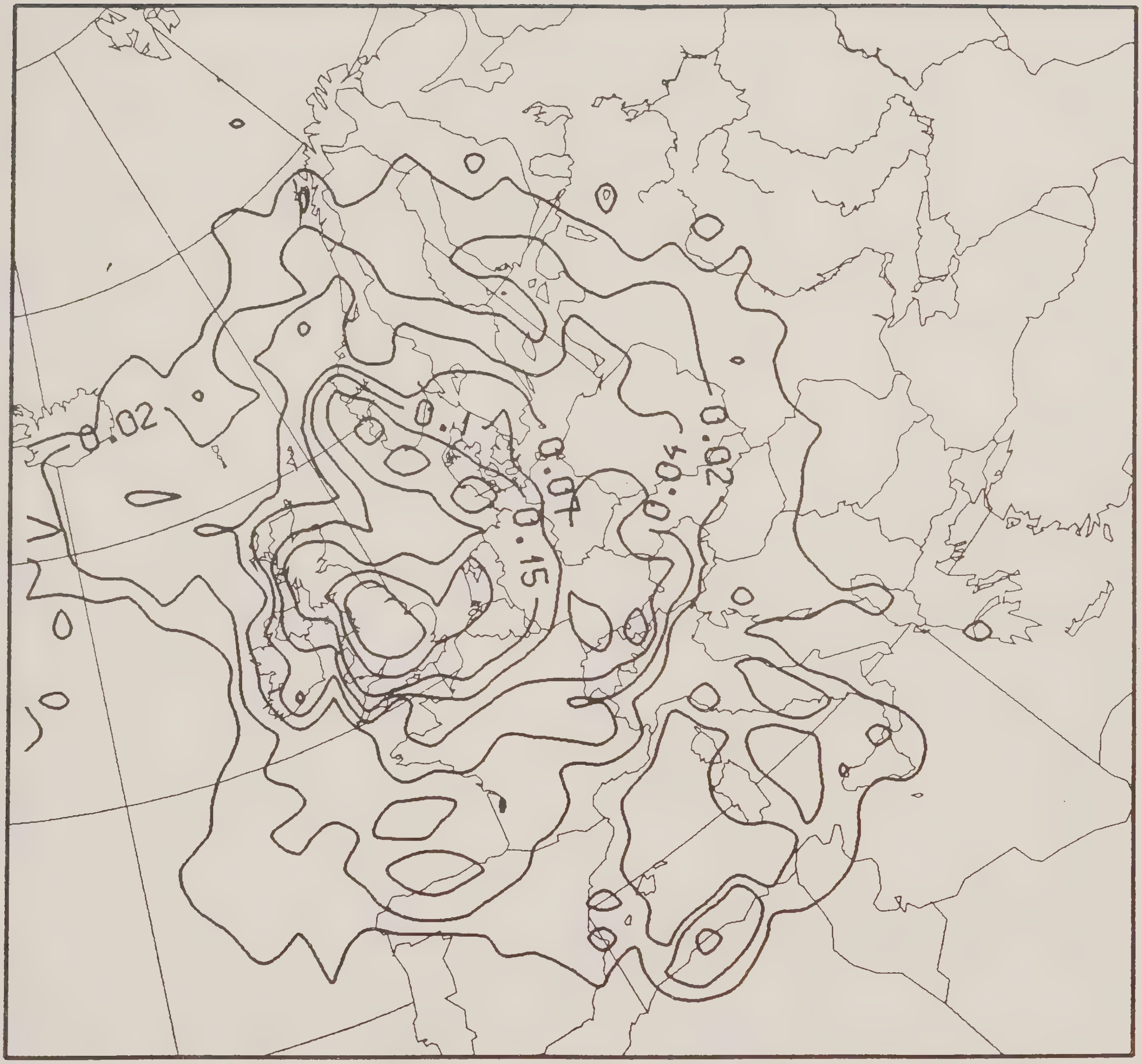

Figure 1 b) Deposition of oxidised nitrogen allocated to emissions in United Kingdom. Calculations for 1988. Isolines for 0.01, 0.02, 0.04, 0.07, 0.1, 0.15, 0.25, 0.4, 0.7, 1.0, 1.5, 2.5, 4.0, 7.0, 10.0 grammes per square meter as nitrogen.

INTERANNUAL VARIABILITY OF S-DEPOSITION

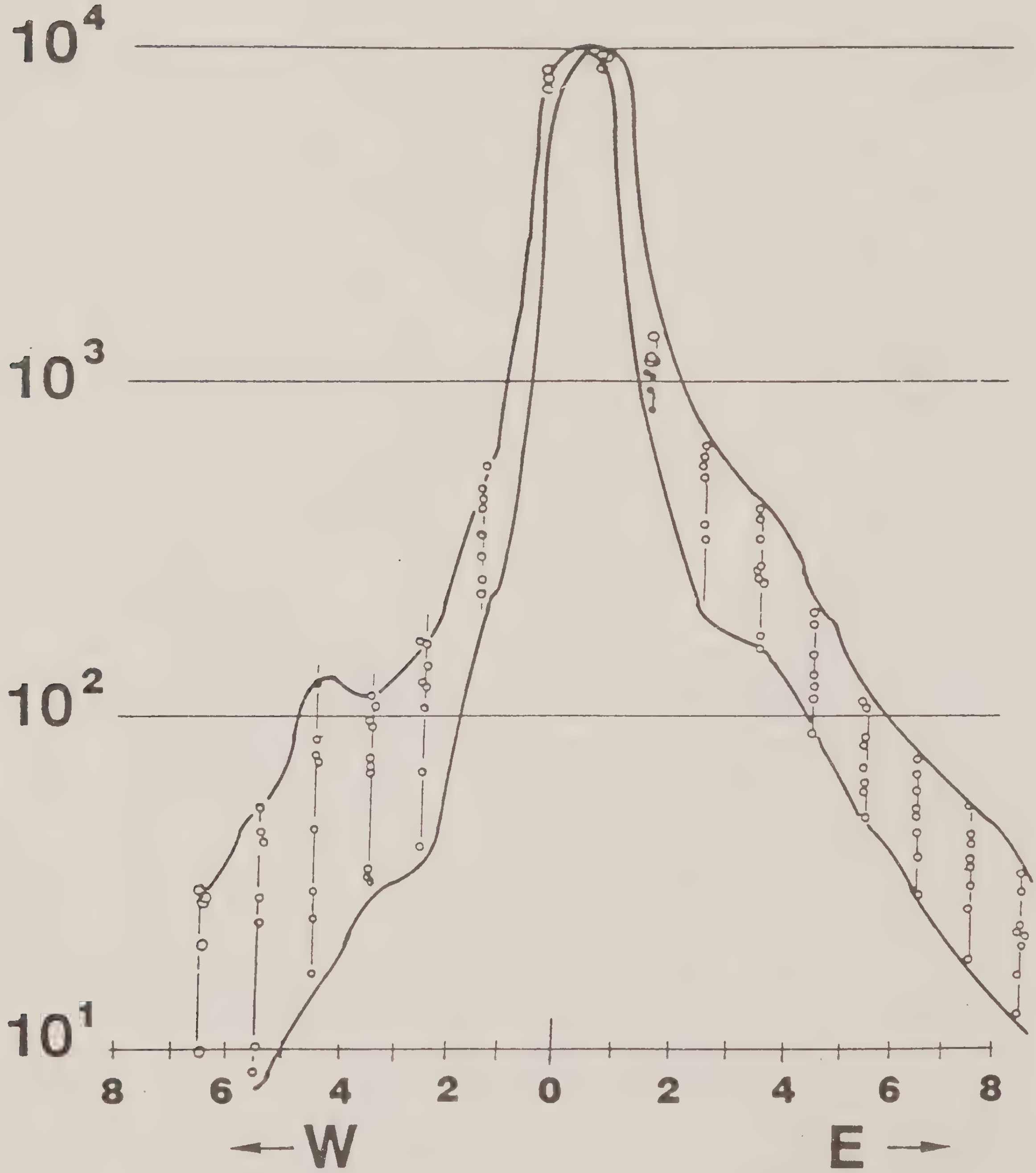

Figure 2. A cross-section in the E-W direction through calculated annual deposition patterns from emissions in the German Democratic Republic normalized to 1980-emissions. The deposition values for each grid-square in the E-W direction is given for 1979-1987 (8 years), in units mg(S)/m^2, and the scale is logarithmic. The two curves are supposed to form upper and lower bounds for the annual depositions given as small circles. The distance between the tics on the abscissa is about 212 km. (Eliassen *et al.*, 1990).

Table 1. The percentage of different countries' emissions deposited in their own area, to Norway and Sweden (NO+SE), and in the whole area of deposition calculation for EMEP. Calculations for 1988 and 1989.

(These numbers are subject to continuous updating as countries change their reported emissions.)

	UNITED KINGDOM		FRG		GDR		POLAND		USSR European part	
	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989
OXIDISED SULPHUR										
Emissions kt S	1830	1773	749	719	2602	2600	2088	1952	5057	4651
Dep. to itself %	24.7	25.4	27.9	30.3	22.8	24.7	29.7	31.1	41.3	37.4
Dep. to NO+SE %	2.5	2.9	2.7	2.2	2.5	1.8	1.8	1.4	0.6	0.4
Dep. to EMEP %	71.3	71.5	72.8	77.1	66.1	71.1	64.1	68.8	50.9	46.0
OXIDISED NITROGEN										
Emissions kt N	754	764	852	821	307	306	472	450	1274	1274
Dep. to itself %	10.1	11.1	15.0	17.4	7.5	9.2	16.1	17.3	30.6	26.9
Dep. to NO+SE %	4.6	5.8	4.1	3.3	4.2	3.3	3.0	2.0	0.8	0.4
Dep. to EMEP %	66.8	66.9	72.8	73.2	67.4	70.9	62.9	65.3	39.6	34.4

Table 2. Allocated contributions to depositions in two chosen EMEP grid-squares. Calculation valid for 1988.

	POINT 1	POINT 2	POINT 3
Geographical coordinate	52 deg.N; 15 deg.E.	52 deg.N; 1 deg.W.	59 deg.N; 7 deg.E.
Calculated S-dep (g/m^2)	12.26	3.99	0.88
Critical Load *) (g/m^2)	0.64	1.28	0.32
Excess (g/m^2)	11.62	2.71	0.56
Percentage contribution:			
Belgium	0.3	0.5	3
Czechoslovakia	5.1	0.3	2
Denmark	0.2	<0.1	3
France	0.6	0.8	5
GDR	86.4	0.8	10
FRG	2.0	0.5	7
Hungary	0.1	<0.1	<0.5
Ireland	<0.1	0.3	<0.5
Italy	0.2	<0.1	<0.5
The Netherlands	0.2	0.3	10
Norway	<0.1	<0.1	2
Poland	3.1	0.3	9
Spain	0.1	0.3	1
Sweden	<0.1	<0.1	1
USSR, European part	0.1	<0.1	2
United Kingdom	0.9	92.5	24
Yugoslavia	0.1	<0.1	<0.5
International trade	0.1	0.5	2
Natural Emissions	0.1	0.3	2
Inattributable	1.0	2.8	21

*) Upper estimate from Derwent (1990) on the basis of Chadwick and Kuylenstierna (1989).

ACID RAIN - NEXT STEPS

CRISIS IN EASTERN EUROPE

Prof. Maciej Nowicki

Under Secretary of State,
Environmental Protection, Poland

Professor Nowicki was unable to attend the Conference due to ill-health. This paper was presented on his behalf by Dr. Romuald Sulima of the Institute of Environmental Protection, Warsaw.

1. Economic Development of Eastern Europe after World War II

In 1945 in Yalta, as a result of the Second World War, the three big powers constituting the anti-Nazi coalition re-divided Europe. Eleven sovereign states, representing 30 per cent of Europe's territory (without USSR), and inhabited by 100 million people, were ceded to the Soviet Union. The Iron Curtain was created, and since then the two parts of Europe developed very differently.

Western European countries worked hard to establish a democratic pattern of statehood, the removal of poverty, and the assurance of freedom and social security to all of their citizens. Also, during the 1950s and 1960s, mostly in industrialised regions such as Manchester and Cardiff in the United Kingdom, the Ruhr and Sahr regions of FRG or the Callais district in France, as well as large urban areas (the famous London smog) the increasing frequency of pollution episodes was recognised as a danger to the environment. In response to those dangers legislation was developed which encouraged better environmental protection and established effective inspection systems to oversee the implementation of the legislation.

Those mechanisms appear to have been effective as today those countries have combined successful reduction of the most dangerous gaseous emissions into the air with a fast growing economy. It is worth noting that in these countries state administrative controls are separate from the economic system.

However, in Eastern Europe, matters have been handled in a completely different manner. The nationalization of land and industry, buildings, forests and natural resources implemented immediately after the War has led to a situation in which the state has become the sole owner of all and everything; the citizens were employees of one huge enterprise. The master -

or state employer - paid very little while at the same time expecting full loyalty and subordination. He alone took the responsibility for health care and social security of the staff. The state authorities, like parliament, government and the administration system were all subordinated to the Communist Party, which influenced the entire economic situation. The rapid development of a large military potential and the achievement of a greater (compared to the West) national income was also strongly promoted. Both these goals could be achieved but only through the intensive industrialisation of our, so far, rural countries, combined with the maintenance of a lower consumption level, and therefore a low standard of living for the citizens.

The results of the first fifteen or twenty years were indeed impressive. A strong iron and steel industry, engineering industry and shipbuilding industry were created; the output from mines and power plants increased by several hundred per cent and electrification of the whole country was carried out. The Eastern European states were quickly joining the industrialised family, and smoking steel mills and power plant chimneys became symbols of economic strength and technological progress.

However, the price of that success was high. Natural resources such as air, water, forests and mineral resources, being free of charge, were exploited in a most ruthless manner. The low and stable price of land throughout the country promoted investment in already industrialised centres offering a labour force and ready markets. Moreover, according to theories adopted from the Russians, huge industrial complexes were regarded as the most effective form of enterprise. The fact that Eastern currencies were unconvertible created a trend towards achieving complete self-sufficiency, which resulted in the ineffective production of an unnecessarily wide range of machinery and goods. That phase of development had exhausted all its advantages by the 1960s and was ended by outbreaks of protest in Czechoslovakia and Poland in 1968 and again in Poland in 1970.

Loans from the West, taken by all Eastern European countries, including the USSR, since 1971, proved to be a life-line for the already ageing industries. The main objective was to buy new machinery and technology from leading Western economies using Western money. It was a very smart idea indeed, and the considerable capital which flowed from abroad was enough to stabilise the domestic situation between 1970 and 1980.

It was in that period, however, that all the weaknesses of the centrally governed economy, including the lack of effectiveness, became most visible. The way in which the

borrowed money had been spent was far from optimum; new technologies were introduced only following much delay. Moreover, the spare parts and various components needed to keep the new plants operating often could not be supplied due to the shortage of foreign currency. Also, it soon became clear that the quality of the goods being produced was low and that they could not be sold on foreign markets. Consequently, there was no way to pay back the loans.

When the time came to repay the loans in around 1980, most of the industry was still outdated and trade with the West in a very poor condition. This led to the growth of social unrest and the birth of the first free trade union "Solidarity", in August 1980. However, it took another ten years of struggle in a country ruined by a growing economic crisis to make the Communist Government understand that it is impossible to rule a nation against its will, to reject competition and as a result technical progress, and to continue without broad international co-operation.

It has become clear that the very centralised economic administration of the socialist system has failed and now that the Iron Curtain no longer exists, the impoverishment of the people, the ageing and exploited industry and the ruined environment of the East can be seen more clearly than ever.

2. Pollution of the Environment

Large scale mineral resource mining had led to the development of huge industrial centres inhabited by millions of people. Steel, power and engineering industries were usually built in the vicinity of mining projects. Chemical plant were placed along large rivers. Today environmental hazards are most severe in these areas. The situation was worsenened by the fact that equipment to reduce discharges of pollutants to the environment were not considered as integral parts of production lines. This resulted in the construction and repair of such equipment being neglected because of financial difficulties and the absolute priority given to production. In effect the environmental protection equipment industry had no chance to develop and is therefore almost non-existent at present in the East European countries.

Up to now, environmental law has been established in such a way that investment in protection of the environment was not encouraged. For instance only the maximum permissible concentrations of pollutants in the air were standardised, but not the amount of emission; there were standards set for classes of water cleanliness for rivers and lakes, but not for the permissible load of pollutants in waste waters. Thus, only the deteriorating quality of environment could be

recorded, and there was no legislation enforcing the installation of environmental protection equipment. The socialist state, being the sole "manager" of the country and the owner of the factories, knowingly made industrial production a priority over protection of the environment and of the health of its citizens. Furthermore, until recently, the results of health and environmnt monitoring were not published; this was to ensure that citizens were unaware of the dangers to them, especially the inhabitants of the most industrialised regions.

Let me give you an indication of the present state of the environment in Eastern European countries, and the resulting hazards. As in other European countries the greatest problem in air pollution control is the need for a rapid reduction of sulphur dioxide emissions. The problem is all the more severe in Eastern European countries as, even without the USSR, they are responsible for over 50 per cent of European SO2 emissions - this despite the fact that electric energy production is comparatively small and comprises only about 20 per cent of European power production. This is chiefly due to the fact that the main fuel in the Eastern European power industry is low quality brown coal. Annual consumption of brown coal in these countries is about 700 million tons, which comprises about 80 per cent of total European brown coal demand. The sulphur content in brown coal is about 9 per cent, the ash content 50 per cent, while the calorific value is often below 10000 kj/kg. Poland, being the only country with large resources of good bituminous coal, has made it the basis of its power industry. However, most hard coal plants are located in the mining region of Upper Silesia. Figure 1 shows the main lignite and hard coal mining areas in Eastern Europe, where most conventional power plants, as well as steel mills and metal works are located. Consequently these are also the most heavily polluted regions. These sources of emission are largely responsible for the acid rain observed in most European countries, and, in effect, for forest damage and water and soil acidification. The proportion of Eastern Europe forests showing damage caused by man's industrial activity are given in Table 1.

The situation is probably most dramatic in the Sudety mountains, where the total destruction of spruce forests is increasing as a result of SO2 emisions from brown coal power plants in Eastern Germany (Saxonia), Czechoslovakia (the Most region) and Poland (Turow power plant). It is shocking to realise that today, as the twentieth century comes to an end, there is still a place in the middle of Europe where land is being turned into a rocky desert as a result of human activity. In the Sudety mountains, the highest levels of acid rainfall in Europe are regularly recorded.

Table 1. Proportions of forests damaged due to industrial activity in Eastern European countries (1988 data)

State	Proportion of damaged forests %		Severely damaged forests as a proportion of damaged forests %	
	All forests	Coniferous forests	All forests	Coniferous forests
Bulgaria	59.5	78.0	2.0	2.3
Czechoslovakia	74.0	73.0	6.0	6.0
Yugoslavia	39.7	66.4	9.7	16.3
East Germany	54.3	57.2	2.6	2.7
Poland	78.0	82.2	1.6	1.7
Hungary	36.4	35.7	2.9	1.6

The mean annual pH value observed at the BAPMON programme monitoring station on Mt Sniezka is 3.8, but rainfall having a pH below 3.0 is not infrequent. Apart from causing forest destruction, acid rain is responsible for a serious fall in agricultural production due to soil acidification, and for considerable losses resulting from increased corrosion of steel and on other buildings.

The results of neglecting water quality protection are as serious as in the case of air. Today, only 4 per cent of rivers in Poland and 17 per cent of rivers in Czechoslovakia carry waters classified as clean, while 30 per cent and 34 per cent respectively are polluted beyond acceptable limits. There is an urgent need in Poland to construct 250 to 300 large municipal sewage treatment plants and several hundred industrial wastewater treatment plants. Their overall cost is estimated at US$5 - 10 billion. The scale of the problem is similar in all East European countries.

The situation with regard to solid waste management is no better. Today, dumping of waste on disposal sites is still practically the only way of getting rid of industrial and municipal wastes. Existing disposal sites are often overloaded and it is becoming difficult to obtain permission for construction of new sites. It is therefore essential to introduce new disposal technologies. It is estimated that the costs of disposal installations needed to solve the problem in Poland alone will amount to several billion dollars. It should be added that Polish industry generates 170 million tons of wastes per year, including 2 million of toxic wastes. About 100 million tons, including 1 millon tons of toxic

wastes, reach disposal sites. This has to changed as soon as possible.

These few examples are enough to show the enormous extent to which industrial regions of Eastern Europe are polluted. Estimations carried out in Poland indicate that material losses resulting from pollution of the environment are equivalent to 5-10 per cent of gross national income. Estimates for Czechoslovakia indicate similar values. Immeasurable health losses such as decreasing life expectancy and abnormally high mortality rates among men in their forties, should be added to this bill. Such is the price we are now paying for advocating the ineffective and long fossilised socialist centralised economy of the past decades.

3. The Environmental Protection Programme

Today, as we radically change the political and economic systems of our countries, for the first time after the war conditions are being created to rapidly make up for the negligence of the past and to accomplish tasks which have already been started. We have to act simultaneously in three important fields:

- changing the law and administration

- changing the structure of our industry

- building emission reducing installations.

Obviously, a new and effective environmental law is essential as a basis for any kind of efficient action in the field of environmental protection. For this reason we are now working on three fundamental acts which will be ready for implementation later this year. At the same time we want to create an environmental "police". Emission measurement, industrial plant control and enforcement of environmental law will be its main duties.

General economic measures having a strong link with environmental protection are the following:

- change in the structure of industry, including a shift from outdated mining, metallurgical and engineering technologies to high-tech industries;

- rationalisation of energy consumption, energy efficiency and implementation of a large scale heat and electricity energy saving programme in industry and housing;

- stimulation of low-waste and non-waste technologies and recycling;

- improvement of production quality.

We realise that these are long term measures and that the first significant results cannot be expected for several years. Nevertheless, these measures will have to be implemented as soon as possible as they are crucial to the future economic development of Poland and other Eastern European countries.

However, the extreme hazards in the most polluted regions of our countries have to be eliminated immediately. It is therefore essential to build sulphur and nitrogen reduction installations to control SO_2 and NO_x emissions from coal-fired power plants, to construct hundreds of wastewater treatment plants, as well as municipal and industrial waste incinerating plants.

The implementation of such a programme in all our countries requires the expenditure of about US$100 billion within the next few years. Although the Western aid received so far is a tiny fraction of that sum, it is regarded as an essential catalyst for our actions and a factor in stimulating implementation of large scale projects. For example, Poland has the possibility of receiving US$200 million of technological and technical assistance from a number of industrialised countries. We will assign that money for

- facilitating modern environmental protection technology transfer;

- transfer of organisational expertise and development of a systematic and broad-based approach to solving problems;

- creation of market-oriented legal and economic mechanisms;

- multi-directional training of Polish environmental protection staff.

We expect that this co-operation will allow us to hasten the introduction of modern and effective ways of reducing emissions to air, water and soil, which should be beneficial to us as well as to foreign firms entering this new, large and so far empty market. We hope that the trends created at present will last and that positive changes for the better will be seen.

I think it is our common desire to see Poland and all the other Eastern European countries meet the twenty first century not only as well established democracies but also as states which respect the priorities of health and environmental protection as principles of sustainable development.

Fig 1. The main lignite and hard coal mining areas in Eastern Europe.

ACID RAIN - NEXT STEPS

REALISTIC REMEDIES - I

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SUMMARY

The former GDR has the highest level of air pollution in Europe. After the oil crisis in 1973 and the resultant replacement of oil, coal and gas by lignite there was an enormous increase in SO_2 emissions. The highest air pollution levels today are measured in the industrial centres of Halle and Leipzig. The end of socialism and the currency, economic and social union with the Federal Republic have also brought about a new start in legislation, as well as in responsibility for the management and implementation of environmental protection.

In June 1990 the People's Chamber adopted the Basic Environmental Law, which was submitted by the German environmental committee and contained regulations for harmonising the environmental legislation of the former GDR with the environmental legislation of the Federal Republic of Germany. From 1 September 1990 the Federal law on immission control applies. In parallel with this, existing structures to ensure effective environmental monitoring will be reorganised and adapted to the new situation; this will enable the necessary data to be obtained and technical reduction measures to be carried out as quickly and as effectively as possible, so that the ecological imbalance in Central Europe can be removed.

This paper was prepared in August 1990. While the GDR no longer formally exists, the designation has been retained for reasons of clarification and refers to that part of Germany as it was prior to unification on 3 October 1990.

1. FOREST DAMAGE AND THE ACID RAIN PROBLEM

Six months before the "change" in the GDR a study prepared by The East Berlin Academy of Science (op. cit. 1) drew attention to the dramatically deteriorating state of the country's forests and demanded drastic measures to reduce emissions.

However, as in previous years, this study was kept secret by the Ministry for Science and Technology. Since the beginning of the 1980s scientists in Tharandt, Eberswalde and Berlin have been monitoring the ecological decline of the forests in the GDR. With a special forecasting and decision-making model for environmental protection they have since been able to make predictions of the development of emissions over a wide area and, based on these data, to calculate the necessary investments for an appropriate clean air policy. The forecasting and decision-making model also gives data on the discharge of pollutants as well as on the development of tree populations for any geographic point in a 10 km x 10 km grid.

These detailed statements which were, however, not published until 9 November 1989, were made possible by interdisciplinary cooperation. This began in the early part of the 1980s. The Centre for Environmental Management and the Meteorological Service developed a propagation model at that time whereby - starting from the polluter - the propagation of air pollutants could be simulated over distances of up to 500 kilometres. All the emission sources from Rostock to Zwickau were logged in an "emission map" and their corresponding SO_2 emissions calculated. The Institute for Forestry in Eberswalde and soil scientists supplied forest and soil data such as needle mass, wood growth rate, population density and pH values of the soils, to describe the actual state of the pine forest for different regions. Today on the basis of the existing and published data and studies it is known from where, for example, the immission load in the air of Leipzig comes: approximately 17 per cent of the average of 200 microgrammes of sulphur per cubic metre of ambient air comes from the works in the Bitterfeld Lignite Combine. Approximately 20 microgrammes of sulphur in each cubic metre of air can be attributed to the emissions of the carbo-chemical works at Espenhain. Even the Düben heath 50 kilometres north of Leipzig is highly polluted: the trees and soil there are contaminated with 300 kilogrammes of sulphur emissions per hectare each year.

In the Environmental Report of the former GDR (2) the following figures are found (1988/89) for damage to forests:

Tree type	**Damaged forest area (%)**
Pine	61.5
Spruce	45.4
Beech	39.0
Oak	52.7

In 1987 almost 70 per cent of the forests (all tree types) were still undamaged, but this percentage was reduced to 56 per cent in 1988 and to 46 per cent in 1989.

According to scientific calculations, in order to protect the GDR pines (of which around 20 per cent have already lost one quarter or more of their original needles) from ecological collapse in the future, there must be a drastic reduction in SO_2 emissions as a first step: according to these calculations processes would have to emit into the air only around 15 per cent of their present SO_2 output; instead of the five million tonnes per year of today, this would mean only 750 000 tonnes per year. At the same time, ammonia emissions from agriculture would have to be reduced by at least half. All the countries of Europe must work together to solve these great and global problems. Only by joint efforts can this task be accomplished in a reasonable time.

The above statements make it clear that very detailed data on the state of the environment were available even before the change. It is, however, obvious that without a specific analysis of the actual state of the environment and air quality, without the necessary financial and practical technical resources and without appropriate legislation, appropriate measures to improve the environment and to prevent forests dying in any country are not possible. In this respect, too, the resources available have gradually and continually improved since the political change in November 1989, so that now "Action" can and must follow in the GDR.

2. ACCESS TO ENVIRONMENTAL DATA

At the beginning of 1990, for the first time after ten years of secrecy, the citizens of the GDR were again given data and information on the state of the natural environment and notified of possible connections with health problems (2 to 4). The political events since 9 October 1989 and 9 November 1989 (opening of the borders) were an implicit requirement for this development.

For example, in the Official Gazette of the GDR, in November 1989, two legal provisions appeared which permitted the publication of environmental data and laid down the requirements for giving smog alarms (5, 6). The Order on environmental data of 13.11.1989 determined the responsibilities of the State control bodies for obtaining, processing and publishing these data. These are

- the State environmental inspectorate for an extensive survey of the state of the atmosphere as well as the

safe disposal of industrial waste products,

- the State water supervisory board for the state of the water and atmospheric precipitation,

- the State hygiene inspectorate for the state of the air, drinking water, foodstuffs, soil and the effect of noise and vibration as well as the safe disposal of household waste.

- the State office for atomic safety and radiation protection (7) for the publication of data on environmental radioactivity.

The Orders take into account the urgent need of GDR citizens for information on the state of their environment. They form the legal basis for the inspection by citizens, publications and firms of the measurement reports of the control and monitoring institutions which are now publicly available. They are obliged to give the public information, for example, on smog episodes, water pollution accidents, chemical accidents and nuclear incidents.

3. AIR POLLUTION IN THE GDR

The environment in the GDR has been particularly damaged because of the structure of its energy source which is unique in the world. Seventy-three per cent of the GDR's primary energy consumption is supplied by the extraction of 320 mill. t of raw lignite (sulphur content 0.6 to 3 per cent). Oil and natural gas amount to only 12 and 10 per cent respectively. As a result, since the oil crisis at the start of the seventies, there has been a constant increase in sulphur dioxide and dust emissions in the GDR. Because of the "replacement strategies" for coke and gas, the emitter groups "households and residential areas" have also contributed to this. While in international treaties the GDR was until recently still working on the basis of an SO2 emission of 4.0 mill. t (from 1978!), a peak of 5.6 mill. t was reached in 1987. In addition to this, there was 2.3 mill. t of dust. In a report from the State Hygiene Inspectorate, it was stated that because of wrong decisions in energy, location and structural policy and a growing discrepancy between ecology and economy, no improvements in the air hygiene situation had been achieved in the last decade.

With reference to the area of the country of 108 333 km^2 and a population of 16 709 mill. (see also Table 1: two states at a glance) pollutant emissions in 1989 were 5.2 mill. t SO_2, 2.0 mill. t of dust and 0.7 mill. t of NO_x. The big

territorial differences in pollution are shown in Table 2.

	GDR	FRG
Population (1989)		
total (in millions)	16.7	62.4
including women (%)	52.2	51.5
births per 1000 inhabitants	12.9	11.0
Area (in 1000 km^2)	108	333
Population per km^2	154	248
Infant mortality rate (per 1000 births)	8	8
Life expectancy (years)	73	75
Gainfully employed millions	8.98	27.31
including women (%)	49	38
Unemployed (millions)	0	2.19
Productivity of labour (%)	49	100
Environmental pollution (1986)		
Sulphur dioxide emissions in mill. t	5.0	2.2
Nitrogen oxide emissions in mill. t.	1.0	3.0
Traffic (1988)		
Length of motorways in km	1855	8618
Electrified railways (km per 1000 km^2)	32	47
Vehicles registered (millions)	3.7	28.9
Income, savings (1988)		
Net monthly wages and salaries per worker (M/DM)	925	2198
Saving as a % of available income	6.5	12.6
Housing industry (1988)		
Dwellings per 1000 inhabitants	421	426
Living area (m^2 per inhabitant)	27.0	34.9
Domestic trade (1988)		
Retail trade turnover (Bill. M/DM)	127	483

Source: German Institute for Economic Research Berlin, 1990, adjusted

Table 1: Two States at a Glance (Prior to Unification)

District	Area km^2	Inhab. x1000	SO2 (kt)	Dust (kt)
Rostock	7075	902	66	43
Schwerin	8672	592	71	32
Neubrandenburg	10948	620	58	40
Potsdam	12568	1121	114	56
Frankfurt/O.	7186	707	127	116
Cottbus	8262	883	1368	436
Magdeburg	11526	1252	180	133
Halle	8771	1791	1054	446
Erfurt	7349	1236	221	119
Gera	4004	741	167	53
Suhl	3856	550	106	38
Dresden	6738	1776	396	216
Leipzig	4966	1378	954	225
Chemnitz	6009	1876	304	100
Berlin	403	1284	70	27
GDR	**108333**	**16709**	**5256**	**2018**

Table 2: Pollutant emissions in the GDR by districts (1989) [according to figures from the district environmental inspectorates]

The GDR is by far the largest emitter among European countries with regard to SO_2 and dust emission per inhabitant at 316 kg or 125 kg per year (for comparison: 120 kg in Poland and 17 kg in the Federal Republic for SO_2). The emission density for SO_2 is 49 t/km^2 and for dust 19 t/km^2 per year. These emission data also resulted in an unacceptably high immission load for 36.6 per cent of the population for SO_2 and 26.3 per cent for dust. The legally prescribed Maximum Immission Concentration (MIC values) are exceeded here in the map areas over the calendar year. In the districts of Halle, Chemnitz and Leipzig as much as 73.3 per cent, 76.5 per cent and 87 per cent respectively of the population are subjected to an unacceptably high SO_2 load, with 2 per cent, 9.6 per cent and 27.7 per cent of the citizens receiving an SO_2 load level of 5 (very seriously overloaded). These figures are 2.5 times

higher than the MIC values of 0.15 mg SO_2/m^3 on an arithmetic mean!

The following table gives an extract from the table of the MIC and TIL (Technical Inmission Limit) values for the GDR. For pollutants with a carcinogenic effect, TIL values have been laid down, as according to WHO medically justified threshold values cannot be given.

(MIC_S = short-term, MIC_L = Long term limit)	**MIC_S**	**MIC_L in mg/m^3**
Ammonia	0.2	0.04
Asbestos*	0.005	-
Benzol*	0.3	0.1
Cadmium* and its compounds (calculated as Cd)	-	0.00005
Chlorine	0.1	0.03
Gaseous F compounds (HF, SiF_4) (calculated as F)	0.02	0.005
Carbon monoxide	5.0	3.0
Sulphur dioxide	0.5	0.15
Dust (non-toxic)	0.5	0.15
Nitrogen oxides calculated as NO_2	0.1	0.04
Tetrachloroethane*	0.5	0.06

(Source: Official Gazette I No. 7 P. 56, 1987; TIL values marked by *)

The trend towards higher values for other pollutants in the big cities of the GDR can also be seen in those recorded for NO_x. However, the figures here of 950 000 t in the Statistical Yearbook for 1988 differ from those in the Environment Report (2) for the same year of 708 000 t (including 300 000 t from traffic) and those in the Air Hygiene Report of the State hygiene inspectorate (2) of 565 000 t of nitrogen oxides in 1989.

Pollution by CO, phenol and H_2S exceed the limit values in city centres, as a result of motor traffic and household fires. In the vicinity of the lignite processing firms in the districts of Leipzig and Cottbus, pollution level 5 occurs

for phenol (Böhlen, Espenhain, Schwarze Pumpe). Considerable odour nuisance is caused over an extensive area.

In 1989 the Meteorological Service measured the maximum mean daily values for ozone at Fichtelberg at 0.196 mg/m^3 and in the town of Meiningen at 0.171 mg/m^3. In the summer of 1990 the ozone limit value of 0.180 mg/m^3 was exceeded for a short time in the centres of the big cities. The major cause of this is the importation of used cars, mostly without catalyst technology, and the massive increase in traffic after the opening of the border.

There is also a considerable air pollution load in the areas around the chemical combines in the centre of Germany at Bitterfeld, Leuna and Merseburg, the metallurgical works of the Mansfeld combine (nonferrous metals), iron metallurgy locations as well as - largely with a local effect - works and areas of the lime and cement industry, cellulose and artificial silk manufacture and the asbestos cement industry.

4. SMOG EPISODES AND SMOG ORDER

The emissions described have in the past frequently resulted in smog episodes in the conurbations of the GDR. Until the political change smog was not a public topic, although the GDR was preparing for the publication of a smog Order. The Environmental Data Order was a prerequisite for the "Smog Order" later passed on 2 November 1989.

There are similarities with the Orders of the States of the Federal Republic in the three smog levels and in the trigger criteria for SO_2, as well as in the determination of smog danger areas (a total of 20). The information level is triggered if the sulphur dioxide concentration in a smog danger area reaches or exceeds the value of 600 $\mu g/m^3$ over 3 hours at 2 monitoring stations and the meteorological forecast leads one to expect a continuation of the load for at least a further 24 hours.

For action level 1, the value of 1200 $\mu g\ SO_2/m^3$ applies, for action level II the value of 1800 $\mu g\ SO_2/m^3$ in air. For level II, only $\geq$ 1200 μg is required at the second monitoring station. When the "trigger-level" is reached the population in the area concerned is informed via the local press and regional radio. Information on current and anticipated levels is given as well as behavioural recommendations. Special citizens information and advisory services are set up and announced via the media. These are run by the hygiene inspectorates, as well as by outpatient departments and local authorities.

The Minister for Health arranges the operational readiness of the authorities and health establishments in the area involved. In particular for children's establishments and for hospitals and outpatient departments specific recommendations are given and measures indicated. The firms in the territory who operate in smog situations in accordance with action plans are informed by the district council (now district administrative authority) and prepare to reduce emissions temporarily to implement these plans.

The regulations applicable for this information level are extended for action level I with a comprehensive information and advisory service, to the restriction of open air events, the reduction of the output of air pollutants in accordance with industrial action plans and the appeal to the citizens to economise on space heating and to abstain from using private cars. The chairman of the district council (government representative) can upon the triggering of action level II restrict the use of motor vehicles totally or in part as well as prohibit events in the open air.

The provision of more measurement equipment at existing air monitoring networks within the framework of the Environmental Agreement (see Chapter 7) have provided new possibilities during 1990 for the adoption of the proven Smog Order Regulations of the Federal Republic. This applies both for terms such as early warning level and first and second alarm level as well as the extended trigger criteria for SO_2, NO_x, CO and airborne dust.

The provisions for anticipated industrial restrictions and prohibitions for plants which require authorization, for the use of low-sulphur fuels etc., are identical to those in the Federal Republic. The industrial prohibitions during the 2nd alarm level do not apply for public establishments in the local authority areas. They do, however, demand restricted use of energy and heat production plants. The new order in general requires that every citizen behaves in such a way that the increase in harmful environmental effects by air pollutants is no greater than is unavoidable under the circumstances.

5. THE POSITION OF AIR MONITORING

Grid measurements carried out in the GDR and the automatic clean air measurement and control systems which already exist in the districts of Dresden, Chemnitz, Leipzig, Magdeburg and in the city of Berlin as well as those being set up in other districts only ensure a satisfactory statement on long-term pollution and acute episodes with air pollutants under certain conditions.

There were 55 SO_2 monitoring stations of the State Hygiene Inspectorate and 45 SO_2 monitoring stations of the Meteorological Service available at the end of January 1990. With the manually-operated monitoring stations using the Impinger method the number increases to 121 and 55 SO_2 monitoring stations.

Supplementing the automatic systems with measurement technology for CO, NO_x and airborne dust measurements is a specific task for the next few years. At the moment the number of instruments avaialable is insufficient for a comprehensive statement, with the result that these pollutants are not listed in the smog order of 02.11.1989. Offers from the Federal Government and from several Federal States will however lead to the provision of metering and transmission equipment and the planned smog early warning system will come into effect in Autumn 1990.

6. THE NEW ENERGY POLICY OF THE GDR UP TO THE YEAR 2000

The GDR holds first place for primary energy consumption per inhabitant in Europe, and world-wide comes behind the USA and Canada in third place. The country consumes 40 per cent more energy per head of population than the Federal Republic of Germany.

As clean air and energy consumption are closely related, special programmes are necessary for

- energy supply as well as
- shutting down,
- modernisation and
- new construction of works.

In the GDR, smog episodes in the towns are largely caused by individual chimneys, such as household fires and small industries. Centralisation of heat supply, rational energy application and optimum availability of low-emission energy sources are, therefore, an essential requirement for prophylactic health protection. The new energy policy also includes as its main requirement a reduction in energy demand by a change in the structure of energy sources.

Among the measures planned are the reduction of lignite production from the present level of 320 mill. t to 180 to 200 mill. t, the increase in coal and coke imports from 5.7 mill. t to 10.6 mill. t as well as increasing natural gas imports from 8 to 18 bill. m^3 per year. This follows the completion of the Stendal 4000 MW nuclear power station and the increased use of renewable energy sources. In addition, thermal insulation programmes for buildings, energy saving household

appliances and waste heat recovery must form part of a new energy saving policy.

The use of gas and district heating will result in the reduction of coal-heated dwellings in the GDR from the current 65 per cent to 45 per cent. Very simple technical requirements for temperature control in dwellings and public buildings are, however, to be created, in order to counteract the waste of energy in housing. In addition there are plans demanded by the citizens and scheduled for the near future to shut down carbo-chemical, chlorine gas and carbide production works as well as the installation of boilers in which lignite is burned in accordance with the circulating fluidized bed principle. The gradual introduction of the power-heat coupling (at present only 5 % in the GDR) will lead to a further appreciable reduction in emissions.

The possible or necessary implementation of the energy policy which has arisen as a result of the tense energy situation, the high level of air pollution and the growing protests of citizens in conurbations (ecological catastrophe areas around Halle and Leipzig!) will also be determined by the heating market of the Federal Republic of Germany as well as by the European heating market. This offers with its excess production the possibility of weighing up the territorial and national aspects of energy policy in Germany and finding optimum solutions for the future. In the long term the power system in the GDR will have to be incorporated in the Western European grid, whereby the coupling systems for feeding into the GDR network necessary at present will become superfluous.

7. THE NEW LEGAL SITUATION: ENVIRONMENTAL UNION WITH THE FEDERAL REPUBLIC

At the end of May 1990 the joint environmental committee of the two German States drew up the outline of a basic environmental law to harmonise the legal provisions of environmental protection. In the preamble to the law passed in the People's Chamber at the end of June (8), reference was made to the fact that the environmental union between the two German states aimed for in the Treaty of 18 May 1990 on the creation of a currency, economic and social union between the German Democratic Republic and the Federal Republic, will be characterised by the basic idea of comprehensive protection of man and the environment, effective environmental safeguards and the guarantee of an environmental assessment test for projects. The law contains appropriate harmonization regulations for immission control, nuclear safety and radiation protection, water and waste management, chemicals legislation, nature protection and countryside care as well as environmental assessment test, which should make it

possible to rapidly adopt the most important parts of the environmental legislation of the Federal Republic in the GDR. The existing regulations of the Federal Republic apply from 1 July 1990, when the treaty came into effect, but no later than the date of accession of the GDR in accordance with Article 23 of the Basic Law of the territory of the GDR; they are embodied in two Annexes to the Basic Environmental Law. The laws, orders or administrative regulations mentioned here relate to centrally regulated areas of the environmental legislation of the Federal Republic of Germany. At the same time European Community environmental regulations become binding for the GDR.

The Federal Immission Control Law applies from 01 September 1990 in the version promulgated on 14 May 1990 (Federal Gazette I P. 880). Hence the legislation on clean air in the GDR ceases to have effect (9, 10, 11, 12).

Immission control is the most important specific area of regulation of the basic environmental law. The aim is, as far as possible to meet the requirements of the law applicable in the Federal Republic of Germany on plant authorization and product-related immission control. At the same time, however, one must take into account the fact that the previous pollution situation, the condition of the old plants, and the administrative structure which will be developed after the creation of the states, will make a certain degree of flexibility necessary in the interpretation of the law in the German Democratic Republic.

Basically, then, for the construction and operation of new plants requiring authorization, the law of the Federal Republic of Germany applies. In the case of old plants, the upgrading policies of the Large Furnace Plant Order and the technical instructions for clean air in the Federal Republic apply - but with extended deadlines. A schedule of deadlines to be adopted by the Council of Ministers for the upgrading of old plants will ensure a rapid upgrading of the old plants. The regulations on the approval procedure take into account the present radical change which the administrative structures are undergoing in the GDR and provide for administrative aid by specialist authorities in the Federal Republic.

The government representative in the district has been specifically appointed as the competent authorization authority (until the formation of the state government after the elections on 14 October 1990), - and the municipal council of Berlin, the State environmental inspectorate of the district or the district government, and in district boroughs the municipal council for the plants mentioned in the appendix

to the Order on plants requiring authorization of 24 July 1985 (Federal Gazette I P. 1586) (13).

In the same way provisions have been laid down on the work of the responsible supervisory authorities, which make broad use of the spectrum of authorities in the GDR. The government representative is the responsible authority for the preparation of clean air plans in accordance with § 47 of the Federal immission control law.

The law of the Federal Republic of Germany and legal regulations, such as orders and administrative regulations, as well as authorization procedures, often make reference to guidelines of the Verein Deutsche Ingenieure (VDI) and to the clean air standards of for clean air. From now these will also be adopted for the territory of the GDR and be applied increasingly there.

With the adoption of the environmental legislation of the Federal Republic, the word health is frequently embodied in the preambles and legislative texts. To date, however, health issues have not been incorporated in the basic environmental law as a ministry or specially allocated to the district health inspectorates responsible for immission control under GDR law. With agreements between the authorities responsible in the districts for environmental monitoring, however, their ability to work is considerably safeguarded in spite of new duties.

In June this year the Federal Government provided further financial resources amounting to 53 million DM for 18 environmental control projects in the GDR. Up to this time the grants provided by the Federal environmental ministry had amounted to 360 million DM. If one adds the grants from other ministries, total investments of 1.5 billion DM are possible.

As an example of a project promoted by the Federal Government, let us describe in more detail the construction of a flue gas purification plant at the Thierbach lignite power station in Leipzig:

The lignite power station (constructed from 1965 to 1971, 840 MW) is to be equipped with modern highly efficient flue gas desulphurisation based on an exhaust gas scrubbing process. As a by-product, a marketable gypsum which can be used in the building sector is produced, for which there is a considerable demand in Leipzig and its surroundings. The investment will amount to approx. 500 million DM; the Federal Government will contribute to this with an investment grant repayable on certain terms of 100 million DM. Because of the high sulphur

content of the lignite burned in Thierbach, extreme demands are placed on the state of the technology for this flue gas desulphurisation plant. In view of these conditions the desired degree of separation of greater than 97 per cent as well as the anticipated emission values are setting a standard for the retrofitting of lignite power stations in the GDR.

The commissioning of the flue gas purification is to take place in the course of 1994 and hence 2 years before the expiry of the deadlines prescribed in the bill of the basic environmental law of the GDR for retrofitting old plants. The SO_2 emissions will be reduced from the present level of around 274 000 t per year to 10 000 t per year!

A prerequisite for financial assistance is the simultaneous technical optimisation and improvement in efficiency of the power station itself. The average efficiency for lignite power stations in the GDR is given as a maximum of 26 per cent. Modern power stations can however achieve up to 38 per cent (14).

One must assume that the lignite power stations in the GDR will continue to be operated to safeguard energy supplies (15). The use of the most modern technology is then all the more necessary to reduce emissions to the required level. The German environmental union is hence both a model and a test for the elimination of the ecological imbalance in Europe and could not only provide examples for economic projects for clean air in the GDR but in the whole of Europe - in the East and West. The time factor plays a decisive part in this, both for ecological and also for economic reasons. Rapid success is necessary in order to show potential and weaker cooperation partners throughout Europe that joint efforts can pay off both economically and ecologically. The protection of our forests is an excellent example of this and at the same time a worthwhile objective.

Literature

1. Die Welt, 13 July 1990, No. 161

2. Umweltbericht der DDR, Institut für Umweltschutz Berlin [Hrsg.] Verlag "visuell", Berlin, 1990 sowie

Berichte der Staatlichen Hygieneinspektion über die Situation auf den Gebieten der Lufthygiene, Wasserhygiene, Bodenhygiene, Kommunalen Lärmbelastung und -bekämpfung 1989 in der DDR Ministerium für Gesundheitswesen, Berlin 1990

(Environment Report of the GDR, Institute for Environmental Protection Berlin [Ed.] Verlag "visuell", Berlin, 1990

and

Reports of the State Hygiene Inspectorate on the situation in the field of clean air, clean water, clean soil, local authority noise nuisance and abatement 1989 in the GDR Ministry for Health, Berlin 1990)

3. Umwelthygienischer Jahresbericht des Bezirkes Magdeburg, 1989
Bezirks-Hygieneinspektion und -insitut Magdeburg, 1990

(Environmental hygiene annual report of the district of Magdeburg 1989
District Hygiene Inspectorate and Institute, Magdeburg, 1990)

4. Umweltbericht des Bezirkes Halle, 1989
Rat des Bezirkes Halle, 1990

(Environmental report of the district of Halle 1989
Halle district council, 1990)

5. Verordnung über Umweltdaten vom 13.11.1989 [GBl. I Nr. 22 S.241]

(Order on environmental data of 13.11.1989 [Official Gazette I No. 22 P. 241])

6. Vierte Durchführungsbestimmung zur Fünften Durchführungsverordnung zum Landeskulturgesetz -

Reinhaltung der Luft - Smogordnung - vom 02.11. 1989 [GBI. Nr. 21 S. 239]

(Fourth implementing regulation on the fifth implementing order on the land improvement law - Clean air - Smog order - of 02.11.1989 [Official Gazette I No. 21 239])

7. Zweite Durchführungsbestimmung zur Verordnung über die Gewährleistung von Atomsicherheit und Strahlenschutz -Daten überUmweltradioaktivität - vom 15.11.1989 [GBI. Nr. 23 S.250]

(Second implementing regulation on the order on the guarantee of atomic safety and radiation protection - Data on environmental radioactivity - of 15.11. 1989 [Official Gazette No. 23 P. 250])

8. Umweltrahmengesetz der DDR vom 29.06.1990 [GBI. 1 Nr. 42 S. 49]

(Basic environment law of the GDR of 29.06.1990 [Official Gazette No. 42 P. 649])

9. Fünfte Durchführungsverordnung zum Landeskulturgsetz - Reinhaltung der Luft - vom 12.02.1987 [GBI. I Nr.7 S.51]

(Fifth implementing order on the land improvement law
- Clean air - of 12.02.1987[Official Gazette I No. 7 P. 51])

10. Erste Durchführungsbestimmung zur Fünften Durchführungsverordnung zum Landeskulturgesetz - Reinhaltung der Luft - Begrenzung, Überwachung und Kontrolle der Immissionen - vom 12.02.1987 [GBI. i. Nr.7 S.56]

(First implementing regulation on the fifth implementing order on the land improvement law - Clean air - Limitation, monitoring and control of immissions - of 12.02.1987 [Official Gazette I No. 7 P. 56])

11. Zweite Durchführungsbestimmung zurFünftenDurchführungsverordnung zum Landeskulturgesetz - Reinhaltung der Luft - Begrenzung,Überwachung und Verminderung der Emissionvon Verbrennungsmotoren - vom 23.01.1985 [GBI. i Nr. 3 S. 18]

(Second implementing regulation on the fifth implementing order on the land improvement law - Clean air - Limitation, monitoring and the reduction of emission of combustion engines - of 23.01.1985 [Official Gazette I No. 3 P. 18])

12. Dritte Durchführungsbestimmung zur Fünften Durchführungsverordnung zum Landeskulturgesetz - Reinhaltung der Luft - Begrenzung, Überwachung und Kontrolle der Emissionen - vom 12.02.1987 [GBI. i Nr. 7 S. 61]

(Third implementing regulation on the fifth implementing order on the land improvement law - Clean air - Limitation, monitoring and control of emissions - of 12.02.,1987 [Official Gazette I No. 7 P. 61])

13. Verordnung über die Zuständigkeiten nach dem Bundes-Immissionsschutzgesetz von 1990.

(Order on the responsibilities in accordance with the Federal immission control law of 1990.)

14. UTECH Berlin - Umwelttechnologieforum 1990 3 Ost-West
Konferenz Umwelttechnik, 26 - 27 Marz 1990, ICC Berlin

(UTECH Berlin - Environmental technology forum 1990 3rd East-West Conference environmental technology, 26th-27th March 1990, ICC Berlin)

15. Umwelttechnik Berlin, UTB Nr. 21/Juni 1990 Märkte - Entwicklungen - Lösungen, Fortbildungszentraum Gesundheits- und Umweltschutz Berlin e.V.

(Environmental technology Berlin, UTB No. 21/June 1990
Markets - Developments - Solutions, Training centre health and environmental protection association, Berlin)

ACID RAIN - NEXT STEPS

REALISTIC REMEDIES - 2

Dr. R. N. Crossett
National Power

INTRODUCTION

As we have heard from previous speakers, perceptions on many factors relevant to the causes, effects and amelioration of acid rain have changed over the past decade and the process is likely to continue into the next decade. Regulatory policy and the emission limits which are set in consequence may thus continue to change.

Realistic remedies should thus incorporate a flexibility which allows for adaptation of the activities which generate acidic emissions to changing standards on realistic timescales. The process should not be viewed in isolation. For example there is little point in rapid progress to a high degree of abatement in the future if the aim is to allow for recovery from previous environmental damage and if that recovery is inherently slow, irrespective of the degree of abatement. That said, I am not going to add to discussion of the derivation for emissions limits and their relationship to environmental science. I stress however, that the process is an important part of any realistic remedy.

I should like to concentrate on the options for abatement of acidic emissions from electricity generation in the UK and the factors which may determine the balance between them in a realistic remedial strategy for the nineties.

PERSPECTIVE

In 1989, 279.5 GWh of electricity was publicly available from UK generators. The fossil fuel contribution to this generation was 80.6 million tonnes of coal, 9.4 million tonnes coal equivalent (mtce) oil and 0.3 mtce natural gas. The balance of supply was derived principally from nuclear and hydro-electric sources, (Figure 1).

To put these figures in perspective, Figure 2 shows that electricity generation accounted for a large part of the coal used in the UK, but a relatively small part of other primary energy sources.

Burning fossil fuel in power stations during 1988 resulted in the emission of 2618 kt of sulphur dioxide which as Figure 3

shows, represented 71 per cent of the UK total. The remaining sulphur dioxide came mainly from manufacturing industry. Electricity generation also resulted in the emission of 792 kt of oxides of nitrogen during 1988, which as Figure 4 shows, represented 32 per cent of the UK total.

Thus, during 1988, electricity generation was the major source of sulphur dioxide emission in the UK, but accounted for barely a third of emissions of oxides of nitrogen. The transport sector was the major emitter.

The 1988 Large Combustion Plant Directive, (LCPD) (88/609 EEC), which is being implemented in the UK under the forthcoming Environmental Protection Act provides emission limits which can be taken as representing the current official view of a realistic remedy for the UK.

The Directive can be seen as a response to the social, economic and scientific perceptions of the '80s. Figure 5 shows that tighter limits are being set for plant licensed after 1987.

Figure 6 shows the National Plan which the UK Government has proposed for achieving the reduction in sulphur dioxide emissions from pre-1987 large combustion plant which are required under the LCPD. Figure 7 shows equivalent figures for oxides of nitrogen.

Limits set for the UK under LCPD will be reviewed by the European Commission in 1994.

ABATEMENT OPTIONS

The total emissions of sulphur and nitrogen oxides from the Electricity Supply Industry depend upon the demand for electricity, the specific emission rates of the combustion processes used to generate it and the contribution of non fossil fuel sources.

The Outlook for Electricity Demand

Figure 8 shows that energy consumption in the UK has grown more slowly than the economy over the past three decades, but within this growth the relative importance of electricity has increased. (Figure 9)

The incentives for energy users to improve efficiency further seem likely to continue, if not intensify so that it can be expected that energy use will continue to grow more slowly than the economy. Equally the convenience, versatility, efficiency at point of use and local environmental benefits

at the point of use of electricity are likely to sustain or improve its relative attractiveness.

In my opinion, it is impossible to estimate with any certainty the balance between these factors in the medium to long term and it would be imprudent to rely on reduced demand for electricity as a major factor in abatement of acidic emissions. Uncertainty in the outlook for electricity demand means that flexibility to respond rapidly and economically to changes in demand will be important to electricity generators. Technologies with short lead times can thus have advantages over those where the time required to come on stream is longer.

The Outlook for Specific Emission Rates from Combustion Processes

Specific Emission Rates depend upon the thermal efficiency of generation, the fuel used (especially for sulphur), combustion process (especially for nitrogen) and the extent to which pollutants are removed from exhaust gases before release to atmosphere.

Thermal Efficiency

As we have seen, the bulk of electricity in the UK is generated by burning oil or coal. The average efficiency of such power stations was 33.7 per cent in 1989.

NP is investing to improve further the thermal efficiency of existing plant.

I believe further gains in thermal efficiency may come from adoption of combined cycle gas turbines and combined heat and power schemes which should also result in reduced acidic emissions. I shall return to these technologies later when I consider their acidic emission characteristics, but first I should like to talk about the prospects for improving the emission performance of conventional fossil fuel burning power stations by fuel substitution and plant modification.

Fuel Substitution

Sulphur emissions are determined primarily by the sulphur content of the fuel burned. British Coal has a narrow range of sulphur content at around 1.6 per cent.

Ample resources of low sulphur coal are available for exploitation. The successor companies to CEGB have negotiated a three year contract with British Coal from April 1990 which means that a high proportion of British Coal will continue to

be used for that period. From April 1993 however, imported lower sulphur coal could make a larger contribution to sulphur abatement in the UK and National Power is examining the potential for building additional coal import terminals to facilitate these coal imports. The attractiveness of low sulphur coal as an abatement option will depend upon the premium which it attracts on the world market at the time.

Lower sulphur oils can be used also to abate emissions from oil-fired stations, but again the extent of abatement depends upon economic factors and the availability of suitable plant.

Plant Modification

Several countries, notably Japan, modified conventional large fossil fuel fired generating plant in order to overcome local air quality problems in the sixties and seventies. The UK remedy was to replace plant in urban areas with large scale plant in areas more remote from centres of population. Equipment of this plant with tall stacks and dust abatement equipment gave satisfactory local air quality, but did not contribute to the solution of problems of long-distance transport of pollutants. Plant modification does however offer the prospect of major improvement in plant emission performance. For example, National Power is fitting a limestone flue gas desulphurisation system (FGD) to its coal-fired power station at Drax. Powergen, the other principal non-nuclear generating company to succeed the CEGB, is also investigating the application of FGD to some of its own coal fired plant. (Figure 10).

The NP system at Drax will have an estimated capital cost of approximately £700m and is due to be fully operational in 1996. It is designed to remove up to 90 per cent of sulphur dioxide from emissions, requiring about 550,000 tonnes of limestone pa in the process. Overall FGD at Drax will add 0.5 p/kwh to generation costs. The figure underlines the cost that can arise from flue gas desulphurisation (FGD). National Power has signed a contract to sell up to 1 million tonnes of FGD waste gypsum per year for the manufacture of plaster and plasterboard. The plant will then produce a valuable raw material from what would otherwise be a waste product.

There are of course other systems for FGD, each with their own financial, environmental and technical problems (Figure 11). Overall however, witnesses appearing before the House of Commons Energy Committee earlier this year were not optimistic that attractive new processes for FGD would be available on a timescale relevant to compliance with LCPD.

Many techniques have been proposed for reducing oxides of

nitrogen in exhaust gas from power stations. In large pulverised fuel plant, burners can be modified to reduce emissions and NP is so modifying burners at our larger coal fired stations. Figure 12 shows how burners can be designed to progressively introduce air into the combustion zone in order to achieve the desired results. Large-scale trials have demonstrated that reductions of between 30 per cent and 45 per cent in nitrogen oxide emission levels are achievable. There is also a range of wet and dry processes for removal of oxides and nitrogen from flue gases which can offer abatement rates of up to 90 per cent. All involve significant costs and can have environmental problems such as those arising from disposal of catalysts at the end of their useful lives.

New Plant

Combined Cycle Gas Turbine (CCGT) plant burns natural gas to drive a generator producing electricity. Hot gases are then passed through a boiler to raise steam to drive a steam turbine couple to its own generator (Figure 13). This enables the CCGT to achieve thermal efficiency levels of around 50 per cent. Natural gas is virtually free from sulphur so that there are practically no sulphur emissions.

The typical designs currently proposed for use in the UK emit about 80 per cent less oxides of nitrogen per unit of electricity than conventional fossil fuel plant. The higher thermal efficiency of CCGT's coupled with higher hydrogenation of fuel means that CO_2 emission per unit of electricity are also reduced to approximately half that of modern coal fired plant with limestone FGD. Until now, development of CCGT's for power generation has been inhibited by European Community restrictions on the use of natural gas.

However, the Commission has now accepted that the national gas reserves are such that its use for power generation does not pose a threat to security of supply and is proposing that the relevant Directive, (75/404 EEC) is withdrawn. The proposal will be discussed by the Council of Ministers later this year.

National Power has announced plans to build 650 megawatt CCGT at Killingholme on Humberside and is investigating other sites for possible future developments of such stations. Other companies have announced plans for CCGT stations at various stages of commitment. Witnesses before the House of Commons Energy Committee in April envisaged that at least 10 GW of CCGT plant would be built in the UK over the next few years. The use of this plant on base load would make a very significant change in the sulphur dioxide and NOx emissions from the UK electricity supply industry.

Development of CCGT's on this scale could increase UK natural gas consumption by around 20 per cent, but witnesses before the Committee thought that supplies would be available at prices which would make base load running of the new stations competitive.

It seems likely then that after 1992, when CCGTS start to come into service, they could play a significant part in the UK's strategy for compliance with LCPD, as well as bringing other economic and environmental benefits.

Gas turbine technology with similar environmental performance could contribute to a development of Combined Heat and Power (CHP) schemes which would also give major efficiency gains by turning what might otherwise be waste heat from electricity generation into useful service.

The Energy Technology Support unit suggests that at least 10 per cent of total demand for electricity might be met by CHP over the next decade, but that the figure could be higher with further development of the technology and greater user versatility in matching heat and power loads on this view. CHP has the potential to make a significant contribution to abatement of acidic emissions in the longer term.

Looking further ahead, a range of advanced coal combustion techniques is under investigation around the world. Various combinations of staged combustion, circulating or fluidised beds, gasification and combined cycles hold the promise of high thermal efficiency combined with good environmental performance. Technical problems are formidable however and reliable economic systems may be some way off. To summarise the position on abatement options, it is clear that there is not a single preferred abatement technology. Rather, there are a range of options which enable an abatement strategy to be formulated in relation to prevailing circumstances and adapted as these circumstances change. Lead-time is an important feature of the various components of the strategy because these determine the speed of adaptation to emission limits and changes in electricity demand.

The greater availability of natural gas and at competitive prices, coincident with the emergence of CCGT technology available on short lead-times, has changed the strategy for abatement of acidic emissions in the UK, not only to comply with the limits of LCPD, but also in relation to the response to other environmental and economic factors.

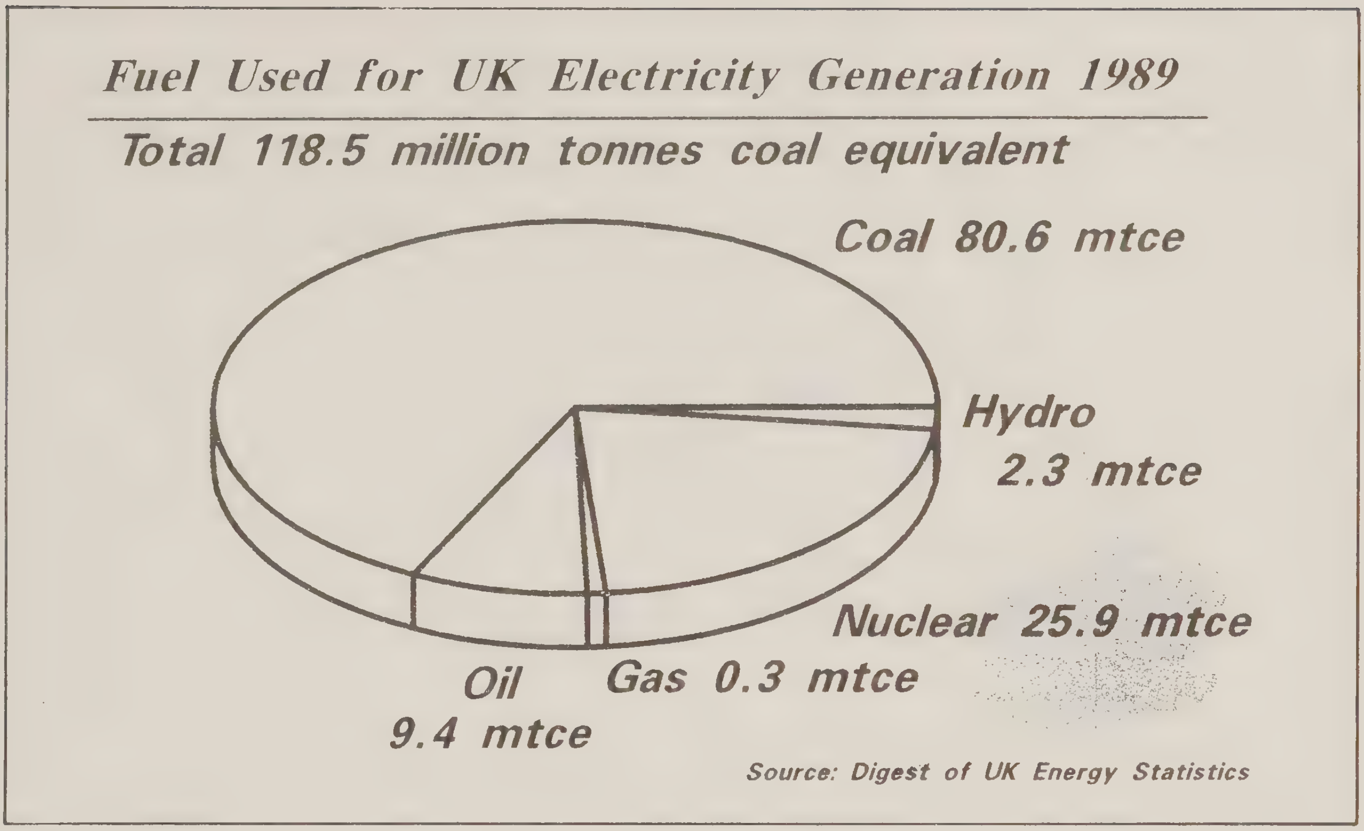


Figure 1

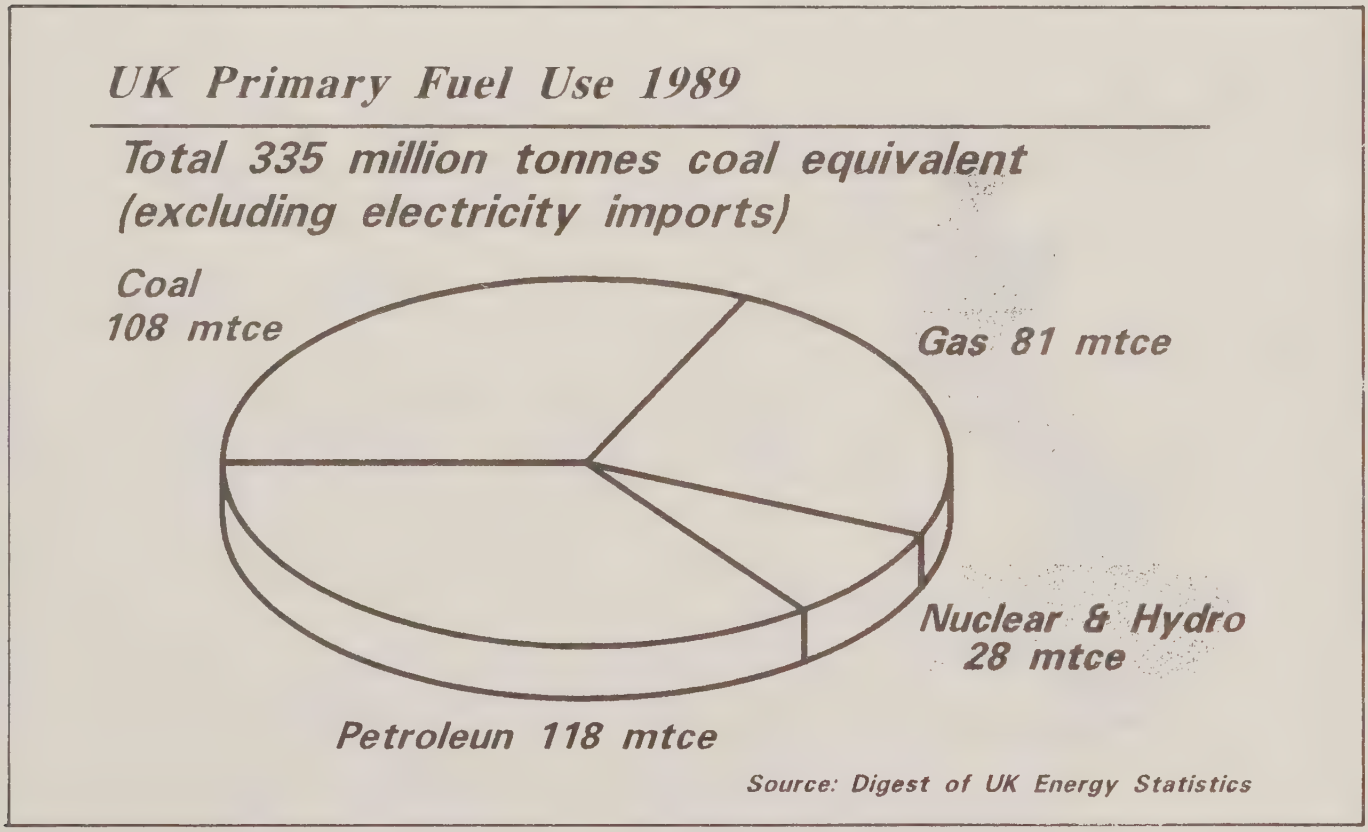


Figure 2

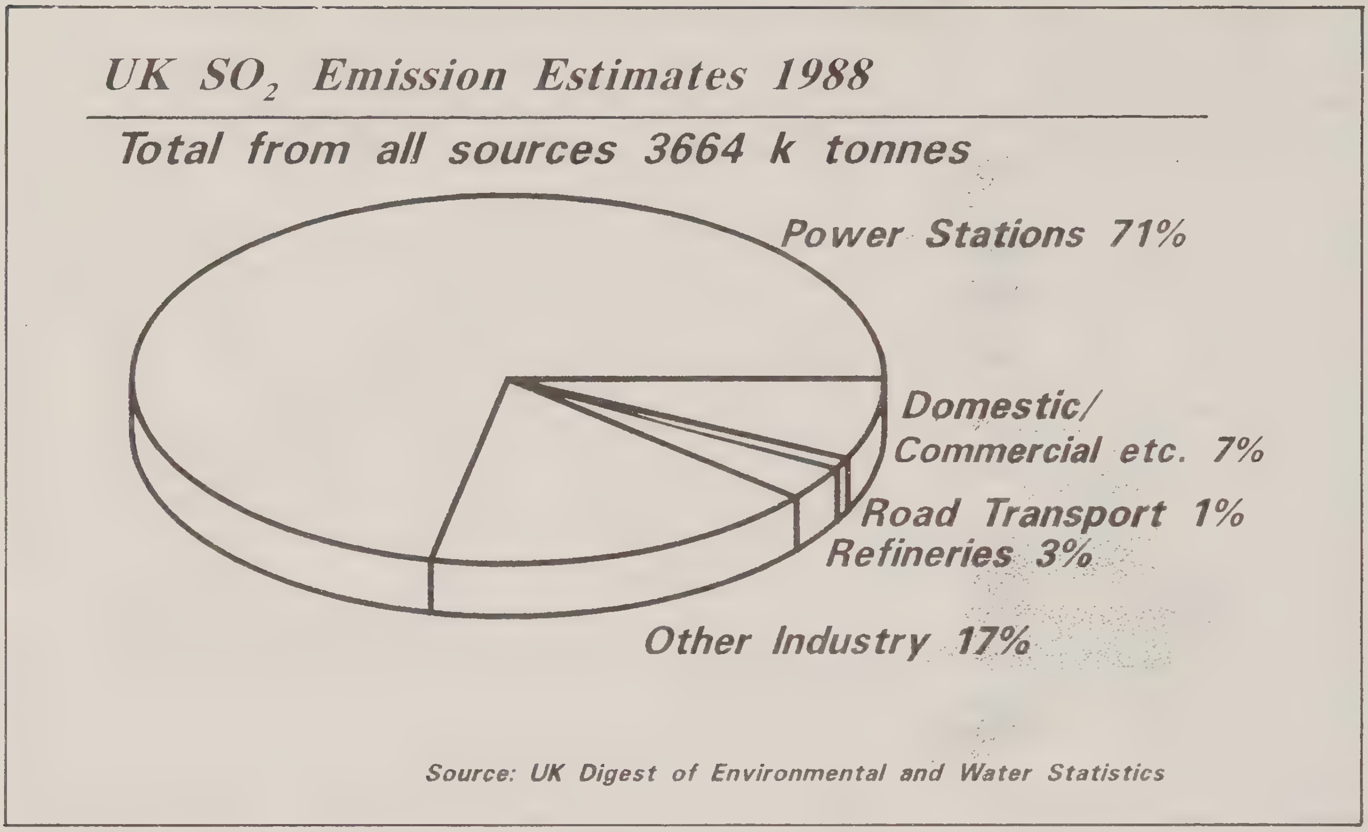


Figure 3

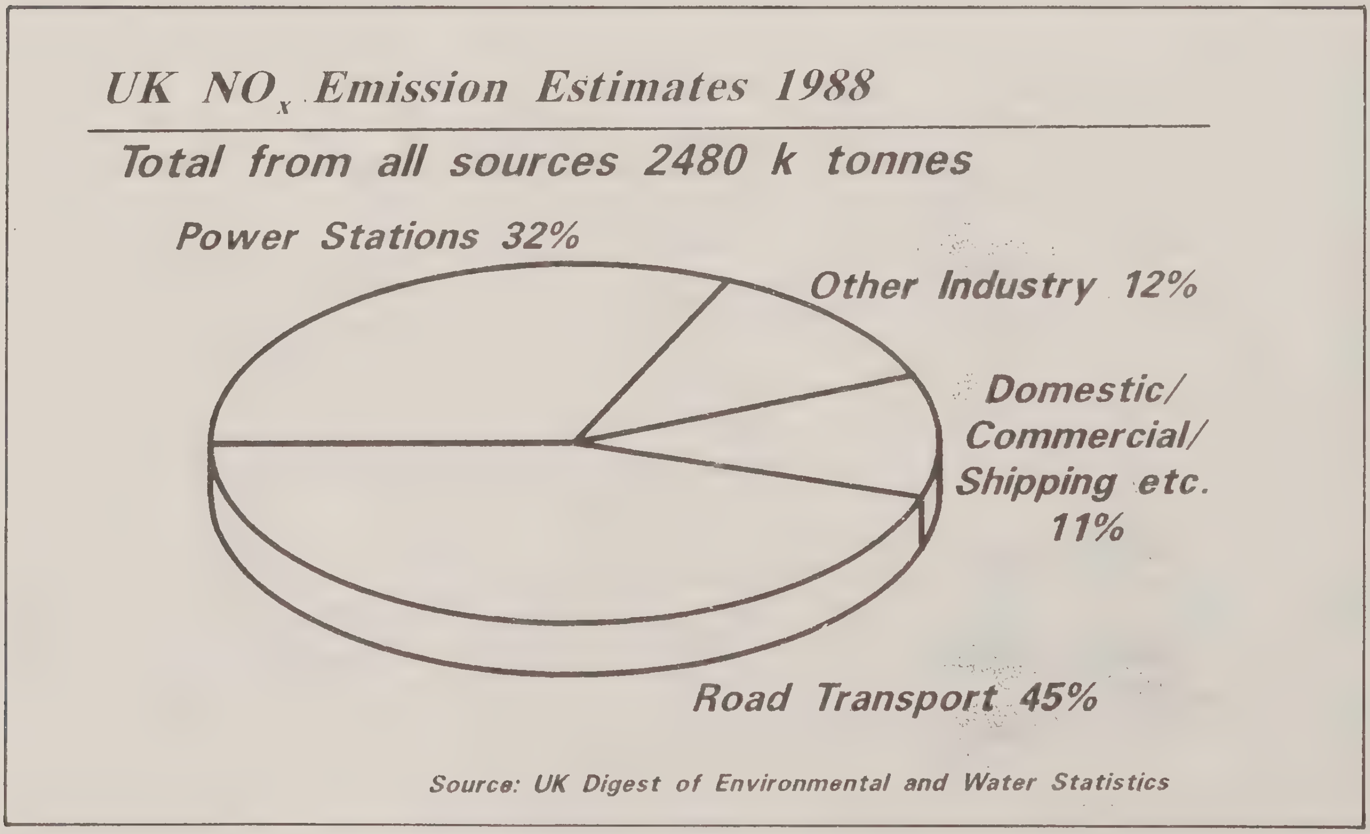


Figure 4

Large Combustion Plant Directive

Limit values for new plant

Fuel	SO_2 mg/Nm ^{3}	NO_x mg/Nm ^{3}
Solid	2000-400 (100-500MW(th))	650
Liquid	1700 (50-300MW(th)) 1700-400 (300-500MW(th))	450
Gaseous	35	350

Source: Department of Environment

Figure 5

UK SO_2 Emission Targets

For pre-1987 plant

Source	Emission k tonne 1980	Proposed Targets (As % reduction on 1980 level) 1993	1998	2003
Power Stations	3006	10	40	60
Other Industry	621	56	63	74
Refineries	268	63	65	66
Total	3895	21	45	63
LCPD		20	40	60

Source : Department of Environment

Figure 6

UK NO_X Emission Targets

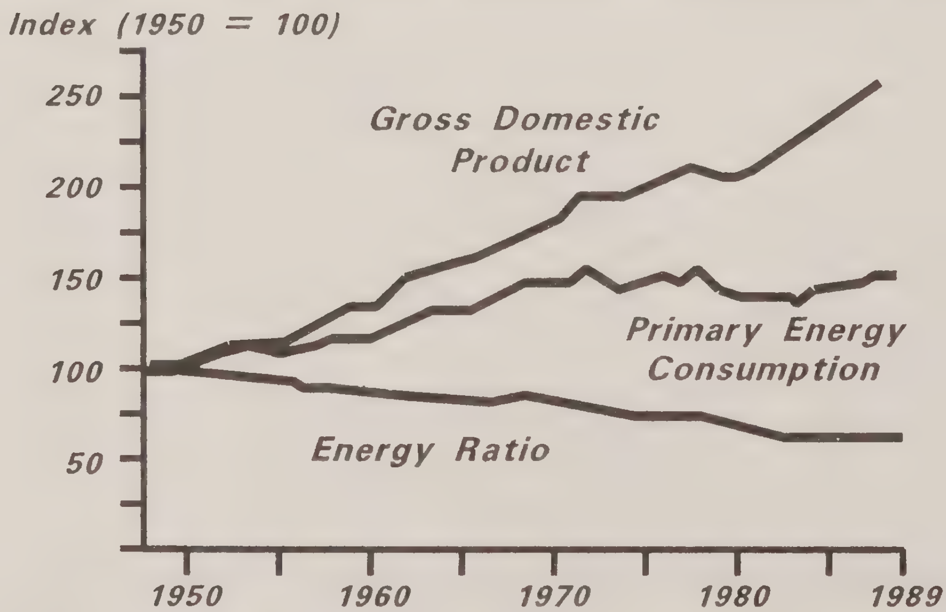
For pre-1987 plant

Source	Emission k tonne 1980	Proposed Targets (As % reduction on 1980 level) 1993	1998
Power Stations	897	17	32
Other Industry	187	52	60
Refineries	43	26	37
Total	1127	23	37
LCPD		15	30

Source : Department of Environment

Figure 7

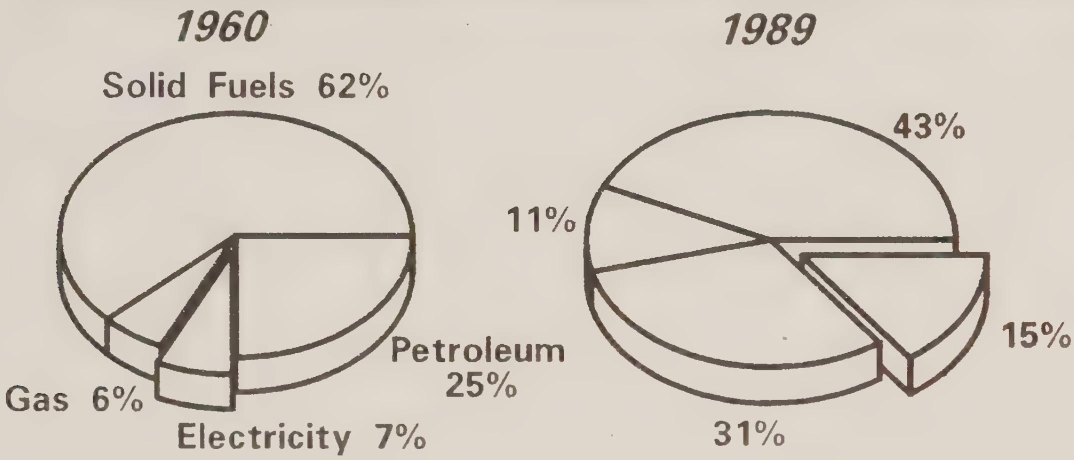
UK Energy Ratio Trend



Source : UK Digest of Energy Statistics

Figure 8

UK Energy Consumption by Fuel Type



Source: UK Digest of Energy Statistics

Figure 9

SO_2 reduction - flue gas desulphurisation

- *Drax 4000MW*
- *Capital cost £700M*
- *On line 1993-96*
- *Adds 0.5p/kWh*

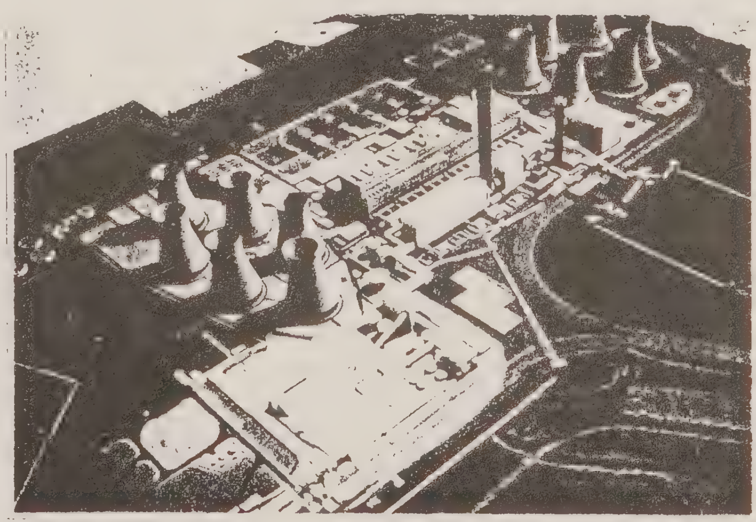


Figure 10

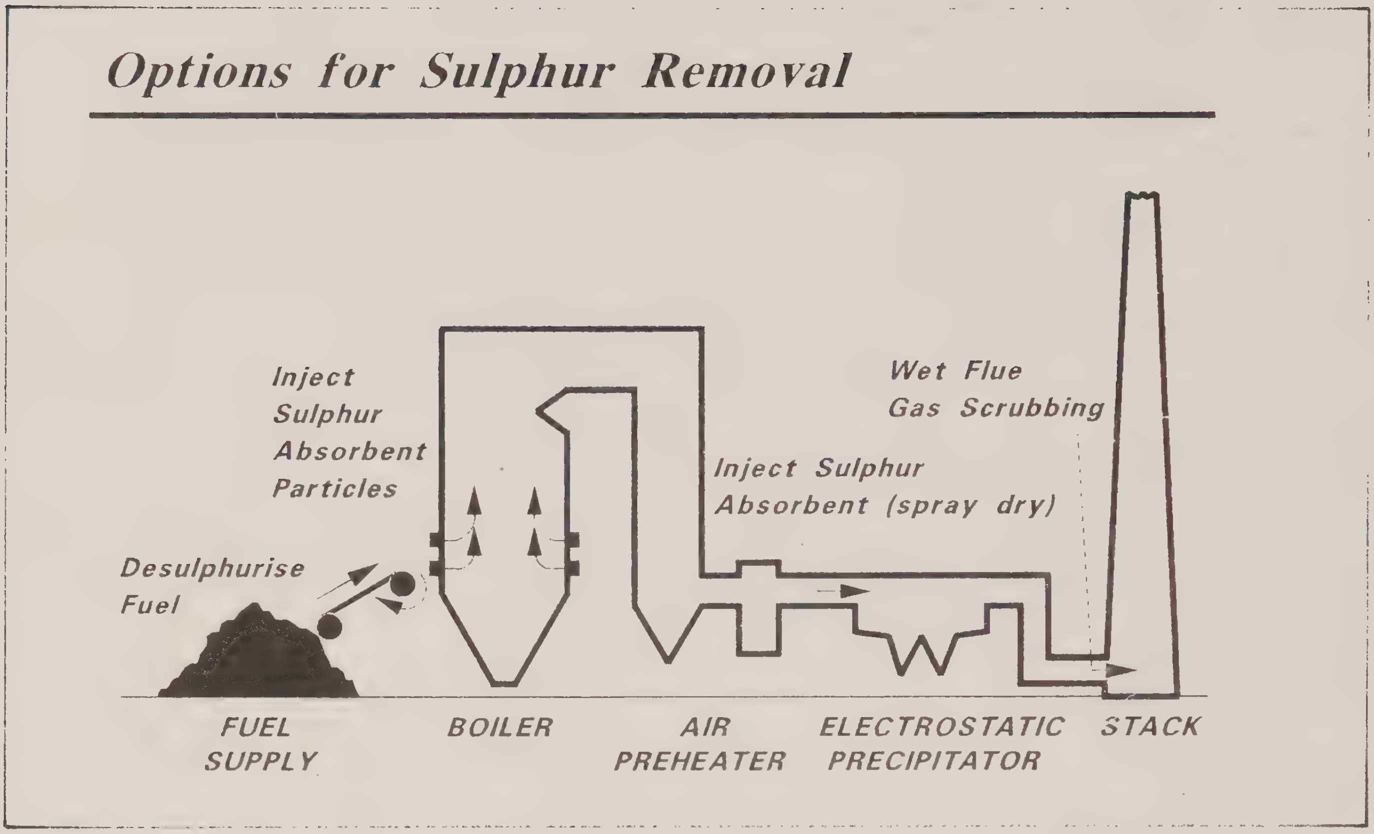


Figure 11

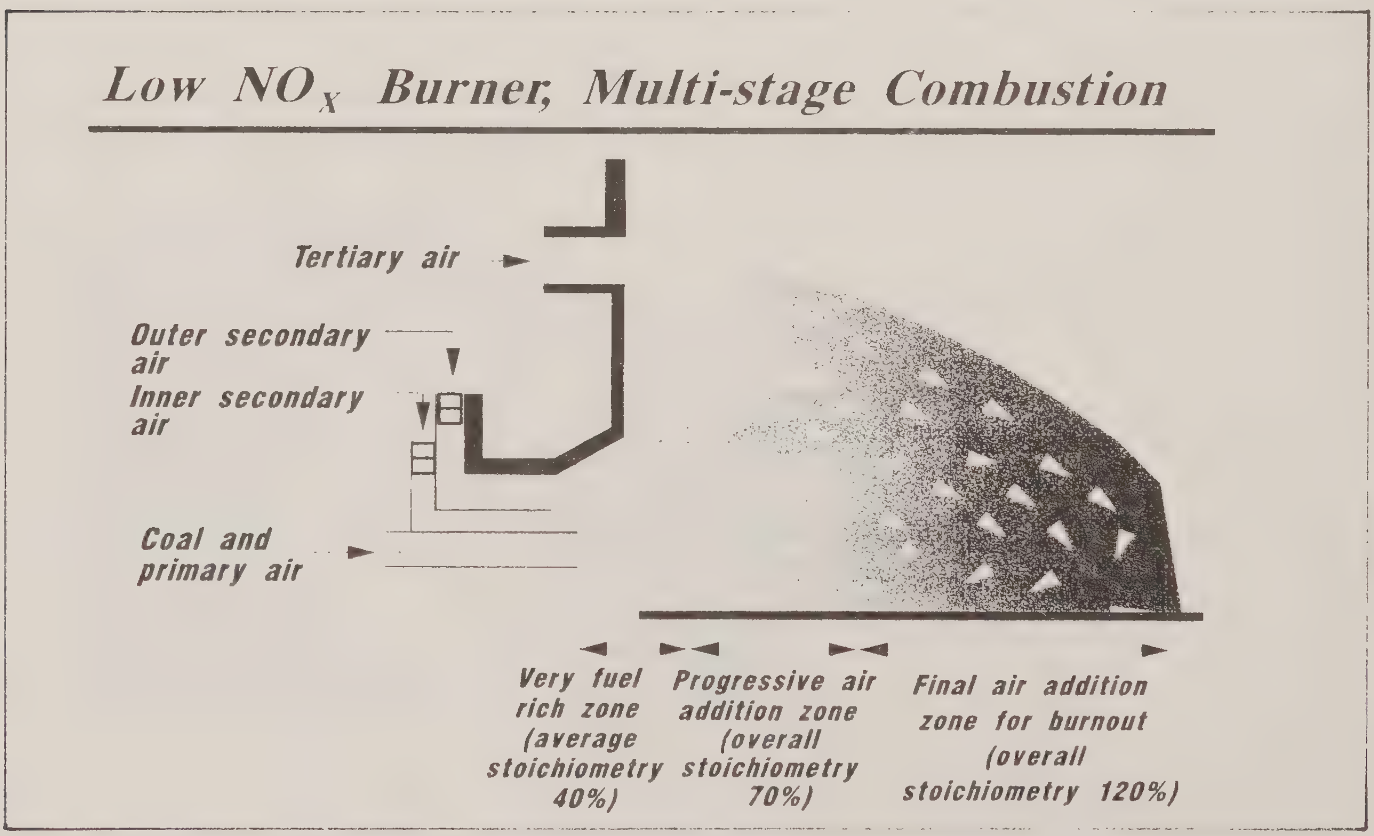


Figure 12

Combined Cycle Gas Turbine

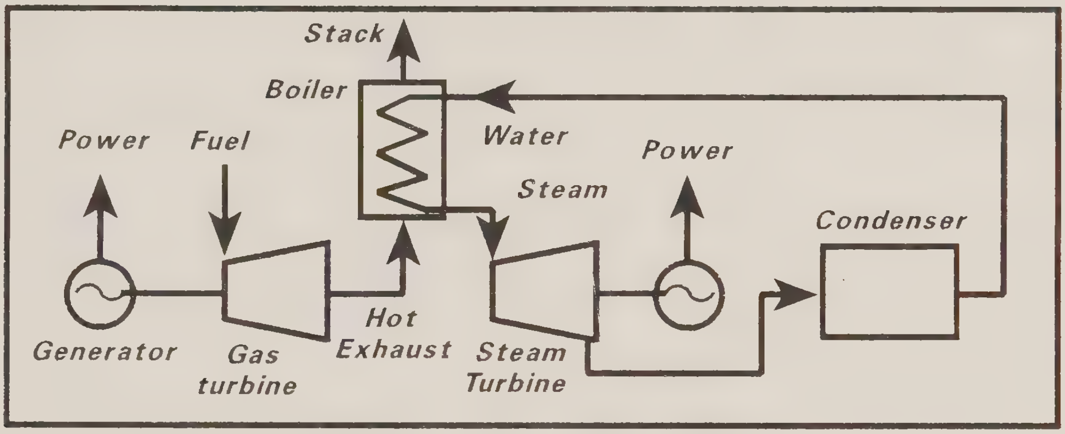


Figure 13

ENERGY AND THE ENVIRONMENT
<u>**Can Nations Agree a Global Energy Strategy?**</u>

THE DEVELOPING NATIONS

R. Sandbrook

International Institute for Environment and Development

I take as my starting point the Intergovernmental Panel on Climate Change (IPCC). Many of you will be familiar with the organisation of the Working Groups 1, 2 and 3 of that significant international effort. The first thing to be said is that the IPCC is an important innovation in the process for reaching a consensus in international science leading to international policy in the environment. It is, when you think about it, remarkable that in the period that was given to them, the scientists have arrived at such a convincing consensus - that has crossed nation states, the borders of different sciences and the north and south divide. This consensus is not adequately based in the south, but nevertheless has made an impact and is a good start. That is a remarkable achievement. So what did the scientists in Group 1 of the IPCC actually conclude? They said:

* We are certain of the following: There is a natural greenhouse effect which already keeps the Earth warmer than it would otherwise be.

* Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases, carbon dioxide, methane, chlorofluorocarbons (CFCs) and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to global warming and further enhance it.

* Carbon dioxide has been responsible for over half of the enhanced greenhouse effect in the past, and is likely to remain so in the future.

* Atmospheric concentrations of the long-lived gases (carbon dioxide, nitrous oxide and the CFCs) adjust only slowly to changes of emissions. Continued emissions of these gases at present rates would commit

us to increased concentrations for centuries ahead. The longer emissions continue to increase at present-day rates, the greater reductions would have to be for concentrations to stabilize at a given level.

* An average rate of increase of global mean temperature during the next century of about 0.3°C per decade (with an uncertainty range of 0.2° - 0.5°C per decade) assuming the IPCC Business as Usual scenario, and this is a more rapid increase than seen over the past 10,000 years. This will result in a likely increase in the global mean temperature of about 1°C above the present value by 2025.

* Under the other IPCC emissions scenarios which assume progressively increasing levels of controls, rates of increase in global mean temperature of about 0.2° per decade.

* Global mean surface air temperature has increased by 0.3 to 0.6°C over the last 100 years, with the five global average warmest years being in the 1980s. Over the same period global sea-level increased by 10 to 20cm. These increases have not been smooth in time, nor uniform over the globe.

  The size of the warming over the last century is broadly consistent with the prediction by climate models, but is also of the same magnitude as natural climate variability.

  Measurements from ice cores going back 160,000 years show that the Earth's temperature closely paralleled the amount of carbon dioxide and methane in the atmosphere. Although we do not know the details of cause and effect, calculations indicate that changes in these greenhouse gases were part, but not all, of the reasons for the large (5-7°C) global temperature swings between ice ages and interglacial periods.

So basically, there is an international scientific consensus on the fact that we are warming up. This is emphasised because, during the course of the summer, there have been some movements from British television, in the press and elsewhere which have brought into question the whole basis of that consensus. I will not comment on that as I believe negotiations will take, as a starting point, the IPCC text. In Geneva in October 1990, there will be a political consensus that warming has to be reckoned with!

In Working Group 2 of the IPCC, which was concerned very much

with the question of impacts, there was also a fairly strong consensus. They concluded:

* Climate change must be viewed in the context of our dynamic and changing world. Large scale natural events such as El Nino can cause significant impacts on agriculture and human settlement. The predicted population explosion will produce severe impacts on land use and on the demands for energy, fresh water, food and housing, which will vary from region to region according to national incomes and rates of development. They concluded in many cases, that the impacts will be felt most severely in regions already under stress, mainly the developing countries. Human-induced climate change due to continued uncontrolled emissions will accentuate these impacts.

They also pointed out that confidence in regional estimates of
critical climatic factors is low. This is particularly true of precipitation and soil moisture, where there is considerable disagreement. Moreover, there are several scientific uncertainties regarding the relationship between climate change and biological effects and between these effects and socioeconomic consequences.

It seems to me that anybody who makes the point that we start out with a series of "knowns" is thus really missing the point. Decision makers are making decisions in a field of great uncertainty.

What are we to make of all this from the point of view of the developing countries? There are basically three reasons why we should address the climate change issue for them very seriously indeed. The first is a moral reason. If they are to be, or may be, in a bit of a pickle as a result of our industrial history, then in a sense, we are morally obliged to consider the effects we may have placed upon them. The moral argument is a strong argument for me, but it does not necessarily carry much weight with people who have been elected as politicians. However, the second reason does make some sense to politicians. If we are going to mitigate the effects of climate change or potential climate change in the Organisation for Economic Cooperation and Development (OECD) region, then we should have a keen eye on the potential of other regions of the world to undo everything that we have done up. Are our policies likely to be overwhelmed, in the long run, by what is going on outside the OECD region or even the United Nations Economic Commission for Europe region? But my third point is the telling one. What is good for climate change abatement, by and large, is potentially extremely good

for sustainable development and poverty relief as well. In fact my thesis is that we are facing a potential "win win" scenario where our efforts to control climate change will also greatly accelerate development for the poorest on the planet and those in the most disadvantageous positions. In other words, the international equity argument or the moral argument which underpins so much of development assistance today, is now reinforced by this new "common benefit" argument.

Returning to the historical story. It has to be recognised that as countries' economies develop, so they have tended to use more and more energy up to a peak of energy use per unit of Gross National Product (GNP). Thereafter energy use as a ration of excessive activity starts to go down as efficiencies take over.

Figure 1 shows in approximate form what has happened. The line for the LDCs - the less developed countries - is highly speculative as far as I am concerned but the key point is clear. They are just beginning to rise up the curve and are nowhere near a maximum. The essential challenge for us is to make sure that the economies which are coming up that curve get over the hump as quickly as possible and into a position of increasing their GNP, while reducing the unit demand of energy that goes into it.

Oakridge National Laboratory have also very conveniently summated the historical position on emissions to date. From this it can be seen in approximate terms who, as it were, come to the climate negotiations with historical responsibility. We can see that 50% of the warming potential around at this point comes from just five countries, if the European Community is included as one big country (which I agree is highly disputable!). This shows the position, taken from 1950 - 1987.

A further extremely interesting analysis has come from the World Resources Institute (WRI) during the course of this year. This does not look at the starting position in terms of the history of accumulated emissions but at the current position. It is a rather sophisticated index of the potential of each economy in the world to warm the atmosphere. These are fairly controversial figures and I am sure that as the years go by they will be refined and argued over greatly. But what they essentially attempt to demonstrate is the composite of global warming effects that each economy makes. They correct the differing warming effects of the individual greenhouse gases. They also factor in the biological sinks or carbon sinks through forest clearance and major land use changes. The World Resources

Institute have come up with an index of countries with the highest greenhouse gas emissions at the present time. From the results it can be seen exactly why an American Institution performed this exercise.

Brazil comes right up to the top of the league table because of the alleged rates of forest clearance. But these figures are highly disputed because the amount of deforestation going on in Brazil as published by WRI is greatly disputed by the Brazilian Government. However, the point remains the same, if we are going to be fair about who in the future is going to have to do what, it is good to factor in biological changes as well as atmospheric concentrations caused by emissions. If we then organise this on a per capita basis, so as to show the league table related to the population in each country, it becomes even more interesting. The result is that Laos is at the top, because at the present time the few people who live there are enjoying an absolute binge of deforestation. Lower down the list you will see the Arab countries. They are there because they are burning off gas at a very high rate through their refining and other activities, with the result that their contribution is significant. What is also interesting in this league table for me is that the countries that are worst in the OECD league table are Australia, Canada and the United States, all of which, in terms of landmass, are extremely large countries. The fashion in an environment business, of which I am a part, is to chastise the United States repeatedly for their failure to do anything about their emissions. Somewhere along the line I think we ought to reckon in that they are actually rather a large landmass and therefore have a lot of moving around to do to run their economy. The important thing is the potential that is shown in this league table if you factor in all of the different sources of warming. If just China and India raised their per capita output to the world average of 1.1 million metric tonnes of CO_2 heating equivalent per annum, the worldwide total CO_2 emission would go up by some 28%. If they were to come up to the level of per capita emissions and heating effect of, say, France, the worldwide addition would increase by some 68%. In effect, the potential for these countries to add to the problem is enormous. This is the second rationale for global action.

The third point is that what is basically bad for the greenhouse is good for development. My argument is that the real victims of climate change are going to be those who are presently most vulnerable to environmental stress. This much has been said by many before. The poor tend, by and large in the world, to live on the margins of the exploitable environment - more droughts, more floods, more rain, whatever

it is, it tends to have the greatest impact upon them first. This point has been enlarged upon greatly by the Chairman of my organisation, Sir Crispin Tickell, who pointed out in his recent National Economic Research Council (NERC) speech, that when people are threatened in this way they will tend to move; they will migrate in great numbers as the stress grows. It should be emphasised again that they may well move for reasons of population increase and many other reasons besides, but certainly the climate effect will make them more vulnerable and therefore make them more deprived, so they will tend to move the more.

Our development objective, in terms of delivered ODA (Overseas Development Assistance) throughout the OECD, is basically to reach the poor. It is my thesis that reaching the poor is not only good for the poor, but is also good for finding solutions to what is being done in terms of our atmosphere. The reason for this is that the poor are totally dependent upon biological productivity for their livelihoods. A colleague in India frequently says that those who live in poverty are not interested in gross national product at all, they are interested in gross nature product. The poor depend directly upon nature for wood, for shelter, for warmth, for food and everything else, and therefore the more we enhance biological productivity worldwide, the more we are likely to enhance the position of the poor, provided that we look after the distribution effects very carefully as we go along.

We should look particularly at food. How vulnerable are the world's food balances under climate change. On balance, Parry[1] suggests that food production on a global basis can, in the face of estimated climate change, be maintained at essentially the same level as now, but the cost of achieving this is not at all clear - it could be very high. However, the most severe impacts will be on those who are currenly most stressed and who are living on the very margins of existance at the present time. Here solutions may be very difficult indeed. We are talking about two broad regions, the semi-arid tropical and sub tropical equatorial regions of South-East Asia and Central America. Here the vulnerability of the poor to changes in food security by climate change is going to be extremely great. Agriculture now has an ability to adjust within given economic and technological constraints, but we basically have no idea at all at the present time how these vulnerable sections of the global community are going to be able to adjust. It is my thesis that, while we have been working with such communities for the last fifteen or twenty years through our aid budgets to try and find ways of maximising their agricultural output and their long-run economic development, so also have we increased biological productivity. We should continue to do

so, but at an accelerated rate for two reasons - it helps the poor and maintains biological sinks for atmospheric carbon. But it is important to establish in more detail the nature of this adaptability and thus help determine critical rates of climatic change that would exceed those that could be accommodated by within-system adjustments. This is a very high priority - maintaining bio-productivity for the poor. In other words, we have much work to do on the development agenda here. Far more could be said about forestry as well but I will pass to energy systems. Many experts have looked at energy policy within the greenhouse context, and they have also come to the basic conclusion that we should make an all-out effort at energy efficiency within the developing regions. We are going to gain in two ways if we do this: first, we will obviously reduce greatly, through energy efficiency, the amount of emissions per unit of output of economy of those countries. But secondly, we will enhance the development objectives of those economies as well. One simple example worked out by a colleague is that of the average cooking stove in Africa. It uses fuel wood and is a tenth of the energy efficiency of the gas stove used in the average family in Europe. Energy efficiency gains for the most mundane of tasks, such as cooking, are potentially enormous and they are there for the taking. However, we will not realise these unless we address the resource base of the economies concerned. Which brings me to the third major point. We need to find new funds.

The challenge at the present time for the northern OECD economies is essentially to work out as quickly as possible how much they will gain per dollar invested at home compared with per dollar invested overseas, in mitigation effects. Will they, in fact, get a better "bang for the buck" when it comes to helping developing countries with their problems than they will fiddling around at home? There is a real need for these relative investment calculations to be made, because we will not see any progress at all in the developing countries unless there are additional, and I mean additional, financial resources. Already the group of 77 are lining up to say, that if climate change means moving money out of priorities set over the last decades into energy efficiency and other greenhouse issues, then forget it, we are not going to negotiate at the table. We will definitely be needing the climate fund, proposed by the bank, which is additional to the present resource flows from north to south. We will also need a new international agency focus concerned with energy efficiency issues. The World Bank should look at that very quickly.

The third area after biological productivity and food and energy efficiency for consideration is in those regions which

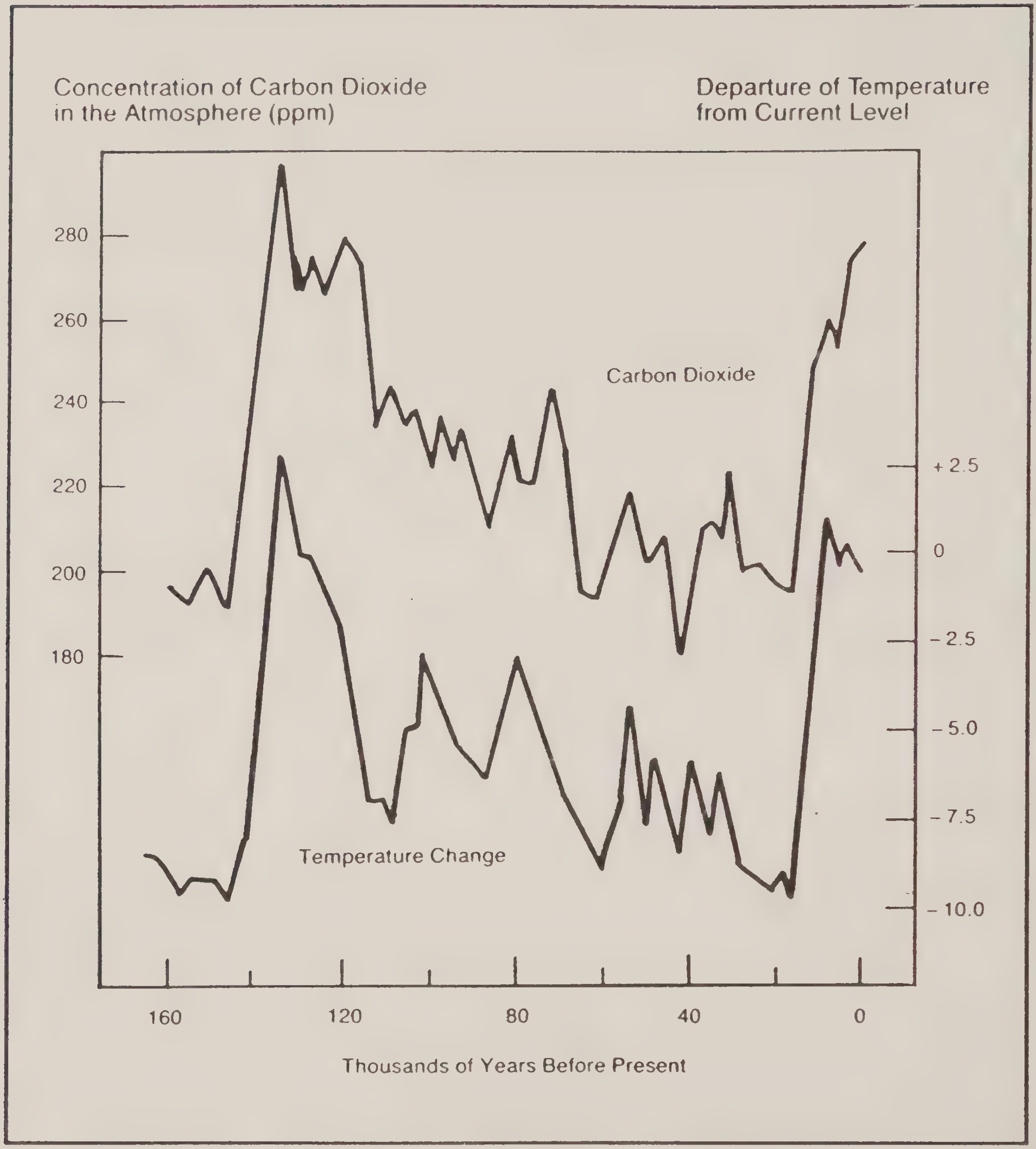
are particularly vulnerable to sea level changes. And here the story is the same. I refer to this not least because Mrs Thatcher was moved on the climate issue as a result of the speech made by the President of the Maldive Islands at the 1988 Commonwealth heads conference in Canada. She may have been convinced by many other things but this certainly had an influence on her. The President, from all accounts is a little man, only about five feet tall. He took a box and then came to the podium to stand on it to give his talk. The way he looks at it, is that not only he but the whole of his island would disappear from view if sea level rises were going to continue. The evidence is such (as presented to the Commonwealth group) that every measure to reduce the vulnerability of island states to sea-level change will be good for their development as well. There are an awful lot of island states and coastally vulnerable communities in the Third World and their problems do need to be faced. But we had to put those problems into proportion. They are not faced by problems of sea-level rise at this minute but by other pressures. The statistics indicate that Bangkok is sinking far faster by over-using its water resources than it is threatened by threats from the incoming seas caused by warming. These development problems are the ones which ought to be addressed as quickly as possible but in ways that also reduce vulnerability to climate effects.

What does all this mean in terms of global conventions? It does not seem to be possible for the world to negotiate an apples-and-orange convention, in which we offset re-afforestation gains in agricultural productivity and the position of island states, against the mitigation of atmospeheric pollutants in Europe and elsewhere. An attempt was made at apples and oranges negotiations in the Law of the Sea Conference. That went on for five years, has never been ratified, was far too complicated and basically got us all nowhere. It is going to be difficult to have a global "let's catch it all" type umbrella convention for climate change. The conclusions of Bill Nitze who suggests that the best thing we can do is essentially go for national targets as quickly as possible would appear to be the way forward. Every signatory to a convention, including those from the developing world, would agree an energy efficiency target, and to improve the ratio of carbon dioxide emissions to gross national product as soon as possible. And every signatory would ensure that no net loss of forests or other biological sinks would occur within the period after ratification. In other words, a national targeted solution rather than an international agreement on a number of precise measures should be our goal. However, all of that will be totally impossible if the question of additional resources to make it possible is not addressed.

So, in conclusion, we are either going to turn our backs on the poor or we are going to help them to join the effort. There are excellent reasons for helping them. Biological productivity as a sink is good for climate change, biological productivity in terms of the livelihoods of the poor is good for the poor. Increasing energy efficiency must help the economies of the South and bring them towards becoming full trading partners with the North. Reducing coastal states' vulnerability also addresses basic development needs whilst minimising the potential for disasters. In effect, what is good for sustainable development for the poor is also very good for us, and it's time to get on with the job.

REFERENCES

(1) Parry, M. - Climate Change and World Agriculture, Earthscan, 1990



Source: J.M. Barnola *et al.*, "Vostok Ice Core Provides 160,000-year Record of Atmospheric CO_2," *Nature*, Vol. 329, No. 6138 (1987), p. 410.

Figure 1: Long-Term Variations of Global Temperature and Atmospheric Carbon Dioxide

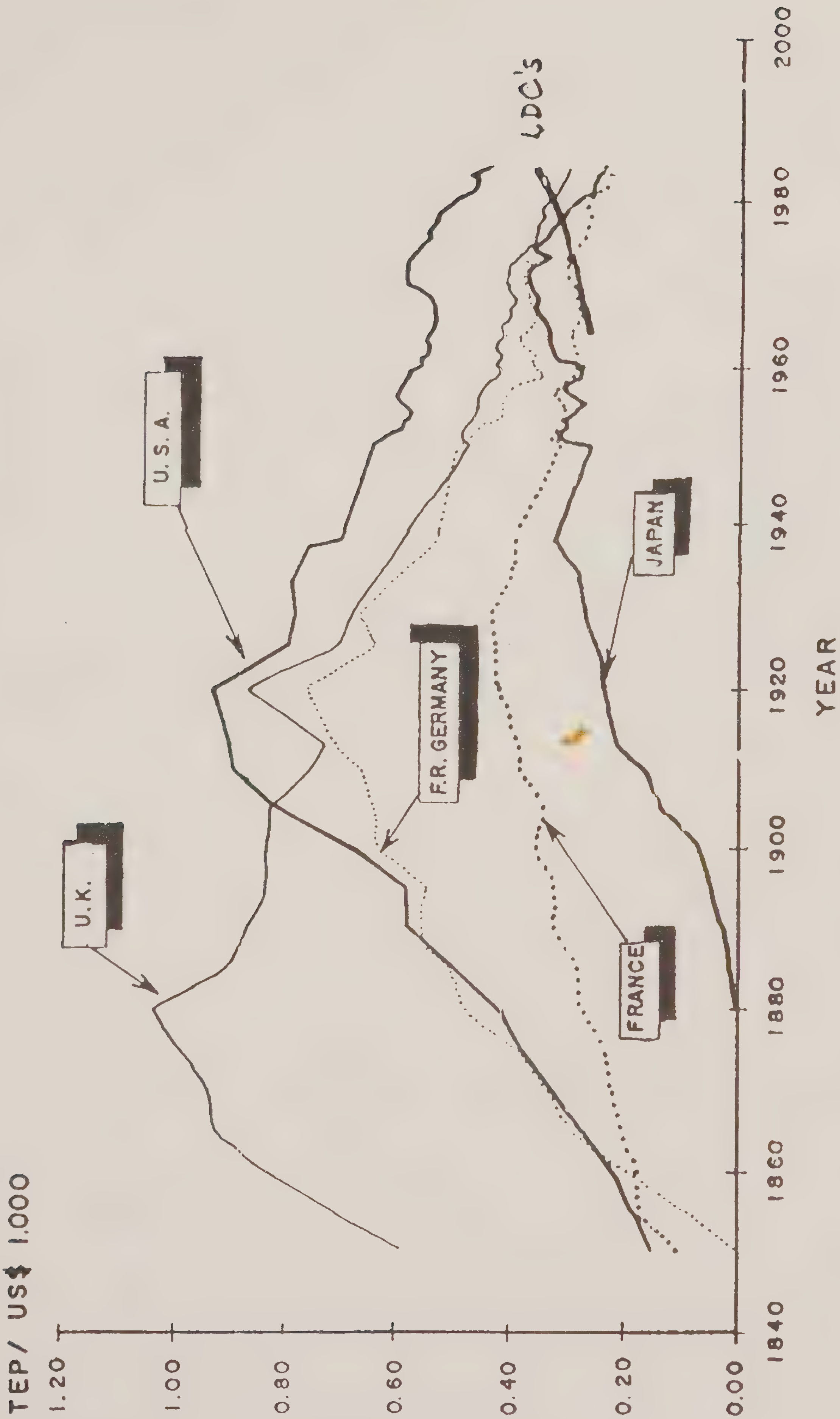
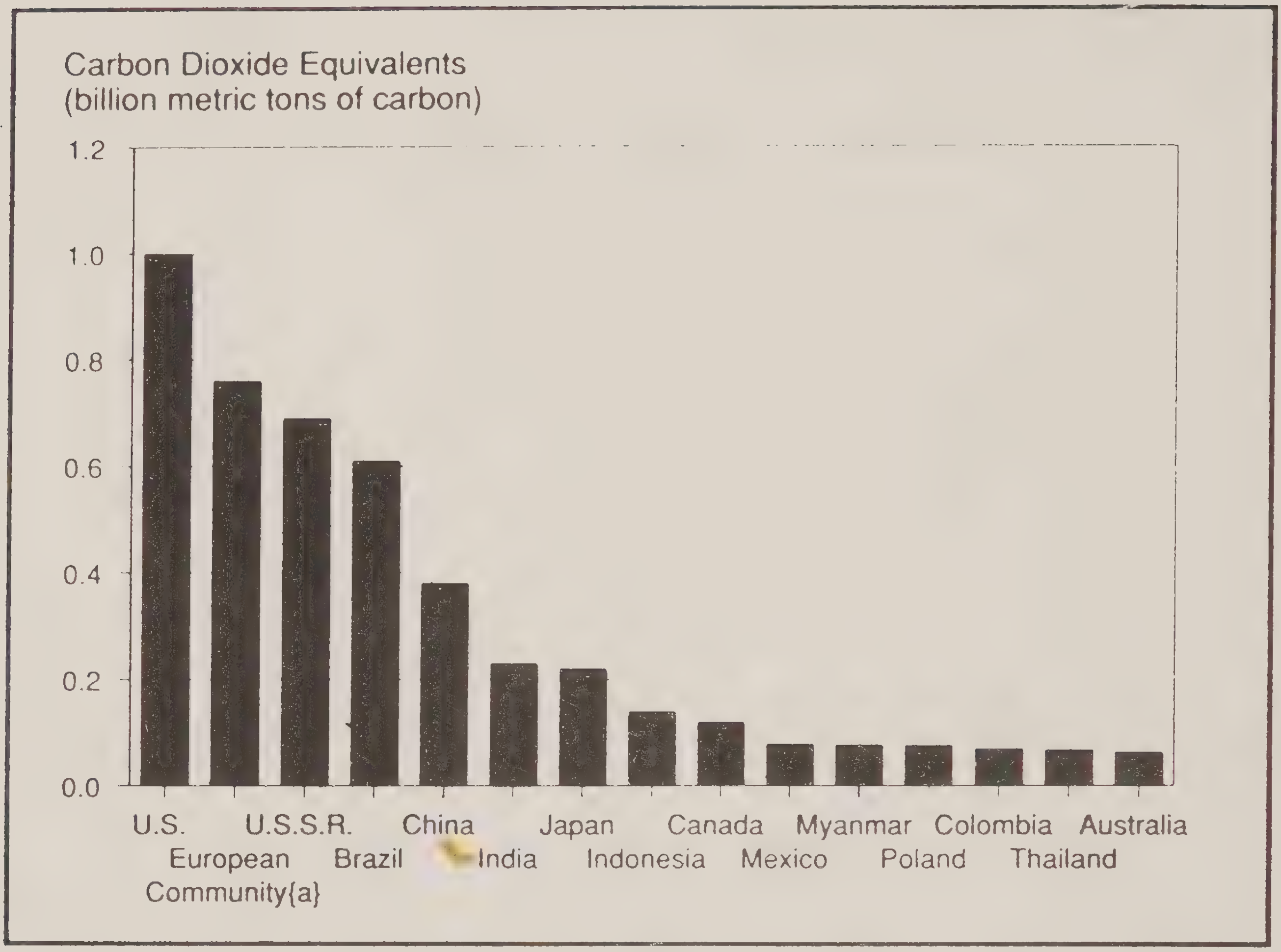


Figure 2: Evolution of the Energy Intensity in Different Countries



Source: Chapter 24, "Atmosphere and Climate," Table 24.2

Note: a. The European Community comprises 12 countries: Belgium, Denmark, France, Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, United Kingdom.

Figure 3: The Greenhouse Index: 26 Countries with the Highest Greenhouse Gas Net Emissions, 1987.

Country	Rank	Metric Tons per Capita
Lao People's Dem Rep	1	10.0
Qatar	2	8.8
United Arab Emirates	3	5.8
Bahrain	4	4.9
Canada	5	4.5
Luxembourg	6	4.3
Brazil	7	4.3
Côte d'Ivoire	8	4.2
United States	9	4.2
Kuwait	10	4.1
Australia	11	3.9
German Dem Rep	12	3.7
Oman	13	3.5
Saudi Arabia	14	3.3
New Zealand	15	3.2
Netherlands	16	2.9
Denmark	17	2.8
Costa Rica	18	2.8
Singapore	19	2.7
United Kingdom	20	2.7
Germany, Fed Rep	21	2.7
Finland	22	2.6
Ireland	23	2.5
Belgium	24	2.5
U.S.S.R.	25	2.5
Switzerland	26	2.4
Nicaragua	27	2.4
Colombia	28	2.3
Trinidad and Tobago	29	2.3
France	30	2.2
Austria	31	2.2
Czechoslovakia	32	2.1
Israel	33	2.1
Ecuador	34	2.1
Italy	35	2.1
Norway	36	2.1
Greece	37	2.1
Poland	38	2.0
Myanmar	39	2.0
Bulgaria	40	1.9
Spain	41	1.9
Japan	42	1.8
Iceland	43	1.8
Liberia	44	1.7
Portugal	45	1.7
Sweden	46	1.7
Guinea-Bissau	47	1.6
Malaysia	48	1.6
Cameroon	49	1.6
Venezuela	50	1.5

Source: World Resources Institute calculation based on Chapter 24, "Atmosphere and Climate," Table24.2.

Figure 4: Per Capita Greenhouse Index: 50 Countries with the Highest Per Capita Greenhouse Gas Net Emissions, 1987.

ENERGY AND THE ENVIRONMENT
Can Nations Agree a Global Strategy?

THE INDUSTRIALISED NATIONS

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1. Introduction

When faced by the OPEC price increases of the 1970s, the OECD countries had a common interest. They acted together to help reduce energy dependence upon the Middle East, and to increase in other ways the co-ordination and resilience of Western Energy systems. Soviet energy developments did not conflict with, and in many ways assisted, this process.

In the 1980s there were various tensions over energy issues: US concerns about the "over-dependence" of Western Europe on Soviet gas; tensions within Europe, and between the US and Canada, over acid rain; and tensions between those who wished to continue strong support for nuclear power, and those who accepted more readily the dominance of market and/or political freedoms to choose or reject it. These stresses and differences, however, did not alter the fundamental common assumption that the future would be built on hydrocarbons, with a door at least kept open to nuclear power as an important adjunct, and with adequate and economic secure supplies being the prime criteria.

Concerns over resources have receded. Despite the price increases following the Iraqi invasion of Kuwait, the Gulf crisis does appear to demonstrate that Western energy systems have become relatively resilient; despite the loss of a substantial fraction of supplies there have been no shortages, and stockpiles had scarcely been touched two months after the crisis began.

The issue of the 1990s is of a different nature, and is likely to be far more divisive. Global warming has emerged from relative obscurity to prominence with astonishing rapidity. It seems to be the issue around which many others will coalesce - energy efficiency policies, energy pricing, the development of gas resources and gas trade, and the development of renewable energy sources. On a wider stage, it has strong implications for the structure of transport and of energy utilities and their regulation, and even wider aspects of industrial structure and international trade and assistance. What are the prospects for developing common energy strategies among industrial countries in the face of the greenhouse effect and such related issues?

2. Current attitudes

Nitze(1) identifies six broad attitudes towards the greenhouse effect within OECD countries at present. The United States is 'very cautious about goals .. for both economic and political reasons'. Japan 'believes that the US and other less efficient OECD countries should bring their energy efficency close to Japanese levels before requiring Japan to make economic sacrifices'. The European countries have been more forward, but there are at least three different perspectives within Europe. The Nordic countries, the Netherlands and Germany have reached 'basic political consensus to press for international agreements to reduce CO_2 and other greenhouse gas emissions even if such reductions require domestic economic sacrifice', and have already made unilateral commitments to reduce their emissions. The southern European countries 'have asked for less strict targets and timetables, citing their lower level of economic development and their smaller responsibility for past emissions.' The UK, with its commitment to stabilise emissions at 1990 levels by 2005 if other countries also do their part, is somewere in between. Canada, Australia and New Zealand have generally supported the Northern European countries, but may be growing more cautious in view of their heavy dependence (Australia and Canada particularly) on carbon fuels.

The attitude of the USSR and Eastern European countries is somewhat schizophrenic, as well as being eclipsed by more pressing concerns. They are among the world's major producers of CO_2, and have few resources to spare for meeting environmental goals; on the other hand, most are keen to be seen to be playing a responsible international role, and could benefit from many of the measures to increase efficiency which would bring down emissions. Important differences between these countries are apparent.

3. Future prospects

Concerns over the greenhouse effect are in a very early stage politically. As the issue develops towards a formal agreement, and grows to a level where it may really affect energy policies, will the differences lessen or deepen, and how important will they be?

Differences are bound to persist within European countries, but the similarities seem likely to be more important than the differences, and the dynamics of the EC process will draw them together still more closely. The EC countries disagree at present over targets and dates, but all the important countries accept the scientific case for action, and agree on

the principle of targets for CO_2 emissions. They share similar environmental perspectives, and all have strong environmental groups. The most important potential abstinee on the grounds of past performance, the UK, is bound into the process by the declarations of Mrs Thatcher and the importance of its scientific constituency, which contains some of the world's leading climatologists and which led the science working group of the Intergovernmental Panel on Climate Change to its forthright conclusions.

The European countries also share much in energy terms. None have cheap coal resources; all bar the UK are oil importers. The combination of dependence on oil and coal imports with environmental concerns is leading the north European countries inexorably towards energy policies which emphasise efficiency, gas and non-fossil sources - nuclear power in France and Belgium, with a growing interest in renewable sources in those which have rejected the nuclear option by decision or by default. All of this makes acceptance of carbon constraints politically easier, and even a useful justification for policies which governments may in any case wish, or be forced, to adopt.

Japan, as a country of exceptionally high energy efficiency and continuing rapid growth in domestic and service sector demands, is currently concerned about any expectations that it should reduce emissions by as much as other countries, and it has traditionally followed the US in most such matters. But the US ties are steadily weakening, and many factors suggest that Japan may adopt a position closer to that of European countries. Japan has no fossil fuel resources to speak of; measures to reduce emissions would carry additional benefits in terms of reduced imports and vulnerability. Environmental groups are growing in strength (though nuclear expansion remains their first focus). Japan is increasingly sensitive to international criticisms, and clearly does not wish to be seen as impeding progress on global warming. But most of all, 'Japan sees its efficient technology as giving it an edge in a world striving to limit carbon emissions; Japan foresees a key role for itself in providing efficient technology to developing countries.'(2)

The attitudes adopted by Soviet and East European countries remain very uncertain, and indeed are likely to diverge considerably as the ties between these countries loosen. Most East European countries have limited fossil fuel resources, and politically, economically and culturally most seem likely to be drawn closer to the Western European position. Current Soviet emissions are high - particularly relative to GNP - and could grow further as non-industrial sectors develop. Furthermore, the vast Soviet energy system contains an immense

inertia, even amid the strong currents of perestroika.

However, emissions might reduce if there is major industrial contraction, and the Soviet position may be strongly affected by the pressing need to increase efficiency anyway, the growth of environmental concerns - many focussed on coal and oil exploitation - and by its abundance of gas and renewable resources.

Amongst all the industrialised countries, by far the greatest difficulties centre on the US position. The current scepticism concerning the rationale for action on the greenhouse effect could change as the debate develops, but it reflects far deeper features of the US energy and political systems which seem likely to ensure that the US attitude remains at variance with that of other countries.

The US energy system has grown on the back of large and cheap domestic energy resources. The US has a relatively efficient and well developed infrastructure for extracting, transporting and using its energy, which together with the vast oil and transport infrastuctures represents immense financial and political investments in existing modes of energy production. Domestic oil may be dwindling, and gas is more constrained than in Eurasia, but the coal resources are enormous and relatively cheap, and are seen as the key to maintaining US lifestyles, built on assumptions of cheap and plentiful energy. Energy prices remain very low, discouraging exploitation of the US's great potential for using renewables, and the political opposition to raising prices is immense. The interests in existing energy systems may be overwhelming: "the democratic and legal mechanisms that distinguish US society will ensure that determined stakeholders have their say" (3). A review of US prospects for reducing CO2 emissions concludes that "the US economy is as dependent on fossil fuels as a heroin addict is to the needle"(4), and recommends US investment abroad to reduce emissions in other countries as a more practical way forward; but even in this respect, the US has been more reluctant than most developed countries.

Yet with about 5% of the world's population, the US accounts for nearly a quarter of global emissions of fossil fuel CO2, and its per-capita emissions are more than double those of Japan and Western Europe. Most other countries believe the US should reduce emissions by more, and should contribute more, than other countries. Yet the US may be the most reluctant of OECD countries to accept even stabilisation or equal reduction targets, and there are clear signs that the US is very wary of commitments to large-scale resource transfers, and is unlikely to change that attitude readily. In fact, the stage is set for an extremely bruising

international clash, exacerbated by wide differences in perceptions of historical and current responsibilities. The US has led many of the world's former environmental efforts, often dragging other reluctant countries behind it(5), and consequently regards with some hostility attempts to lecture it concerning global environmental affairs. It has often been the largest single contributor to international funds, and so regards charges of international meanness with equal distaste. Strong domestic environmental policies have been charged with substantial economic losses, and powerful lobbies now exist to oppose any further major environmental measures or agreements. Furthermore, most US citizens are entirely unaware of the extent to which their whole lifestyle is so exceptional in its use of energy as compared with other countries: heavy reliance on large cars, large houses with large refrigerators, heated often without any timing controls, and with air conditioning regarded as one of the necessities of life in much of the country.

Most US citizens see nothing exceptional about their position, and in so far as they are aware of how US emissions compare internationally, many believe theirs to be a justifiable special case. Yet what is considered normal in the US, most other countries see as immense profligacy with energy. To most observers in other OECD countries, and above all in the developing countries, the US is rich, wasteful and irresponsible both in its domestic energy consumption and policies, and in its international attitude to the greenhouse issue and resources transfers more generally.

Some agreement on carbon emissions among the OECD countries may be possible, but it would be very difficult to achieve. A real common energy strategy may be more difficult still. The gulf between the US position and attitudes and those of most developing countries is so large that it is almost impossible to see how there could be a global agreement on energy strategy and CO2 emissions unless it were so emasculated as to achieve very little of substance. To judge from the situation in 1990, the language which would be required to accommodate both India and the US, for example, would be entirely inadequate to create either the kind of incentives which could break the US 'addiction' to fossil fuels, or the kind of assistance and motivation which could prevent India from getting hooked further on them as it developed.

In fact, the world may be faced with the prospect of having the centrepiece protocol of global efforts to tackle the greenhouse effect lacking in one of three key aspects. Unless there are major changes in attitudes, it must lack one of: the US; the major developing countries; or all teeth and impact.

None of these is attractive. The last may be the most likely but it also seems the least desirable. The developing countries hold the key to long-term emissions growth, and their participation, at as early a stage as possible, seems immensely important. A protocol without the world's largest emittor of greenhouse gases is hardly appealing. But if forced, moving along this road could perhaps be the best of a bad bunch.

In 1980, the idea of a major international agreement on the biggest of all environmental issues proceeding against the wishes of the United States would have been unthinkable, but the relative decline of the US economy during the 1980s means that this is no longer the case, though it would still be an extremely serious departure. But an alliance between the European Community, Japan and the major developing countries, especially if the USSR did join, would place immense pressure on the US. If under these conditions the US attitude did change to such an extent as to allow an effective agreement including all the key countries, the prospects for global abatement could be favourable. But there would presumably also be some chance of such a process driving the US into isolationism on this issue, probably taking some other countries with it. This would give far poorer prospects for global emissions. If the protocol contained provisions which involved economic sanctions against non-participants - and many would argue it must, to survive - this could have serious repercussions on the overall structure of international affairs.

4. Conclusions

Industrialised countries do not currently agree on approaches to global warming. There is little sign that they will; indeed, the divisions could readily deepen as the policy implications become clearer. Global warming seems set to be the issue around which other deep differences, on other environmental and broader energy issues, coalesce. It is doubtful whether the broad sympathy between OECD countries on energy issues will survive; new and different alliances will emerge, with very different tensions. The prospects for agreement on international energy strategy even within the OECD seem poor; the issues relating to energy in developing countries could add further divisions. It is to be hoped that this analysis is incorrect. The conclusions are certainly not happy ones. But the prospect of continuing and expanding global dependence on fossil fuels, with a variety of damaging environmental and other implications including the unknown risks involved in rapid and unprecedented changes to the earth's atmosphere, could be much worse; and that is the realisation that will drive the process.

REFERENCES

(1) W A Nitze, The Greenhouse Effect: Formulating a Convention, Royal Institute of International Affairs, London, October 1990.

(2) M Grubb, Energy Policies and the Greenhouse Effect, Volume 1: Policy Appraisal, Dartmouth/Gower, October 1990.

(3) S Rayner, 'Prospects for greenhouse gas policy in the US energy sector' in M Grubb et al, Energy Policies and the Greenhouse Effect, Volume II: Case Studies and Technical Options, Dartmouth/Gower, forthcoming 1991.

(4) ibid.

(5) For an excellent account of the US view of CFC negotiations and the extent to which the US set the pace, and the implications of this for US attitudes on climate change, see R Benedick 'US Environmental Policy: Lessons for Europe', International Environmental Affairs, 1(1) Spring 1989.

ASSESSING THE ENVIRONMENT

PRICING THE ENVIRONMENT

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In the period of a decade the perspective of environmental problems has moved from the relatively parochial: damage or loss of particular sites or examples of semi-natural habitats, pollution of named rivers; to the international: acid rain, pollution of the North Sea; and finally to the truly global in the form of threats to the integrity of the atmosphere as a life support system through holes in the ozone layer and global warming. The destruction of tropical rain forests falls in this last category since the consequential destruction of genetic stock impairs the capacity of the biosphere with and without human agency to withstand the sorts of stress that global warming seems likely to entail.

The Pearce Report(1) argues that the genesis of these problems lies in economics; they are manifestations of market failure. They arise, that is, because the value of the environment is not reflected in the prices that goods and services command in the market place. The solutions to these problems are thus procedures to correct these market failures and allow the market to operate properly to ensure the maximum welfare of the societies whose artefact it is. The proposed market solutions may be summarised as follows:

(i) environmental damage occurs in the public sector because environmental effects are not valued in public investment appraisal. The solution then is to incorporate environmental values into cost-benefit analysis of public sector projects and to ensure that all such projects are subjected to such analysis.

(ii) for the private sector the main problems are those of various forms of pollution. These are to be dealt with by a variety of fiscal measures the principal ones being:

   (a) pure pollution taxes. Taxes per unit of emission of pollutants

   (b) tradeable pollution licenses

   (c) green taxes. Taxes per unit of output of goods and services which are graduated in some manner to reflect the degree of environmental damage that the production and consumption of the good

incurs. Green taxes are essentially a device for consumer markets. The premium on unleaded petrol is an example. The major one discussed in the Pearce Report was a carbon tax as a contribution to containing global warming.

Despite its stated commitment to the value of the market the recently published White Paper(2) makes no more than a ritual genuflection in the direction of the programme of the Pearce Report. An analysis by a correspondent to The Times(3) credits Pearce with one and a half sentences plus an appendix which does no more than list the options. The object of this paper is to offer an explanation of why this should be(4).

At the outset it should be noted that market failure cannot be taken seriously as an explanation of the origins of the environmental crisis. Much of the damage to the ozone layer was done before the problem was recognised and a similar point can be made about the build-up of CO_2 in the stratosphere. Indeed the extent and nature of the problem is still a matter of scientific dispute. While it is a function of markets to distribute information they cannot be criticised for failing to distribute information that did not exist. The market failure explanation must be taken as a parable which assists in the understanding of the programme of action. The dangers of treating parables as though they were literal truths are sufficiently well known to require no further comment here.

The starting point of a critique must be the traditional economic model of pollution. This also is best considered with a simple parable. My neighbour has a lawn which she cuts with a lawn-mower which disturbs my rest on summer evenings and Sunday afternoons. I see her and offer payment in return for reductions in the frequency of lawn cuttings. Since we are both reasonable people a bargain is struck. She has longer grass than of late but receives monetary compensation which she can use to visit the park where the grass is to her liking; I am poorer but can have longer periods of rest in my deck-chair. Since the bargain was freely entered we are both in our own judgements better off in consequence. The limits to agreement can be readily appreciated: the frequency of cuttings is reduced to the point where the maximum that I am prepared to pay for further reductions in disturbance is less than the minimum that my neighbour would be willing to accept in return for seeing the grass grow longer. This simple parable gives us several concepts:

(i) the (economically) optimum degree of pollution. This level is determined by my willingness to pay compensation and my neighbour's willingness to accept

it

(ii) the optimum pollution tax. This is equal to my willingness to pay compensation (equals my neighbour's willingness to accept compensation) at the optimum degree of pollution. The significance of this concept may be seen if, instead of an innocent gardener my neighbour were a civil airport authority which disturbed my peace along with that of a large number of other local residents. We might find it impossible to pool resources to bargain for our peace but if some representative authority were to undertake to achieve the same object by levying a tax then the summation of our willingness to pay for reduced disturbance would determine the appropriate tax level.

The assumptions made which gave these concepts are as follows:

(a) the sufferer perceives the pollution and is able to evaluate its effects on himself in the form of a willingness to pay (wtp) compensation

(b) the source of the pollution is known to the parties concerned

(c) property rights are accepted in the sense that the direction of income transfers in a free bargaining situation are agreed.

(d) the transactions are unambiguously defined in time and space; at the time that the problem is treated all polluters and pollutees exist.

The reality of the environmental crisis breaches all of these assumptions. Thus:

(i) In many and indeed in almost all the important cases the pollutee does not perceive the pollution. It is identified for her by a third party who identifies it statistically eg as an increased incidence of mortality or disease or conceptually as a problem on the basis of scientific theory.

For this class of cases pollutants are discovered or invented. They are not perceived directly by sufferers. If I am worried about lead in petrol it is because someone has told me what happens not because I have observed it.

(ii) many pollutants only become such above certain

concentrations in the receiving medium. Below that level they may be environmentally benign (e g nitrates in water). The level at which the problem is to be treated as a problem is often a matter of scientific dispute and thus is liable to change over time. The sufferer has no direct role to play in this process.

(iii) the source is often unknown or diffuse. This can be a problem where pollution arises as a result of the cumulation of substances which were not recognised as pollutants when they were emitted to the environment.

(iv) the sufferers may not exist; they could be generations to come. This gets to the heart of the environmental crisis since the major global problems of global warming and depletion of the genetic stock are of this kind. Current generations may actually benefit from these effects: the much reported quote from a farmer that if this was global warming he wanted more of it is believable if apocryphal; and in any case it is far from clear that the costs of preventing the problem are justified to current generations by the perceived benefits.

(v) again most clearly with the global problems the issues of property rights are most decidedly not settled.

Thus it is clear that environmental problems in practice bear little relation to the simple parable of the noisy lawnmower. The consequences of these considerations are straightforward

(i) Since the sufferer does not directly experience the pollution she has no clear willingness to pay. Indeed in the circumstances wtp cannot have the meaning assigned to it in the simple parable. At best it could only apply as a short-hand for something radically different from that illustrated in the parable. My view is that it has no proper domain here at all.

Of course there are survey based techniques for obtaining estimates of willingness to pay. The most popular is contingent valuation with stated preference as the other major approach. Valuation is dependent on the information provided on the nature of the problem, on the respondent's ability to assimilate the information supplied and on her strategic behaviour which in turn depends on the purposes she perceives for the exercise. These techniques work best (although even then there are many objections to them) for valuation of specific environmental assets (eg threats to a

specific site). They cannot be used to derive a marginal social cost curve for a pollutant. Nor do they seem likely to provide estimates of the value of anything to future generations. They are in that sense at most private not social valuations. It might be argued that we are seeing here a process of self deception Lacking the direct experience of pollution the analyst doesn't know what his or her willingness to pay is so she asks the public who typically having less understanding than the analyst don't know either. This doesn't arise in the traditional model since the effect is directly perceived as a nuisance.

(ii) There is no economic optimum degree of pollution. This of course is no serious inconvenience and there is nothing mysterious about how pollution targets are set. They are set on the basis of scientific evidence or hypothesis mediated through the political process. Targets are fixed to avoid deleterious effects on health and take account of the needs of future generations Depending on the nature of the problem these may be seen as ceilings or desired levels, mandatory or advisory.

Because of their dependance on scientific knowledge they are always provisional and may be expected to evolve. Pearce himself pointed out that there is no logical connection between such environmentally fixed targets and the optimum degree of pollution in the economic sense.

(iii) From this it follows that there is no optimum level of green tax nor any unique measure of the social cost of any action with environmental consequences. Let us consider the implications for the market approach as outlined in section 1.

Valuation of the environmental costs of public expenditure programmes is problematic. Numbers may be put in to cost-benefit appraisals but their interpretation is always open to question. It is of course always possible to estimate opportunity cost valuations Thus where there are implications for public health the authorities may calculate the additional expenditures on medical services, the output foregone from increased incidence of sickness etc. In the presence of a fixed standard an unambiguous opportunity cost valuation arises eg if a ceiling level for greenhouse gas emissions is determined then the opportunity cost of a given programme is some other form of economic activity that must be foregone in order to keep within the target. But these opportunity cost valuations have no organic relationship to wtp concepts and there is no reason to believe that the resulting summation of

decisions based on opportunity cost valuations will be within the pollution target set.

There is no natural level for pollution taxes. The traditional theory held that if a tax equal to Marginal Social Cost is imposed pollution will automatically reach the optimum level. With pollution levels fixed as described this will not happen. Opportunity cost valuations of marginal social cost do not have the behavioural consequences of willingness to pay measures.

There are other arguments for the use of pollution taxes as an alternative to the imposition of standards enforced through the legal system.

(a) standards are met at least cost because the polluters with the lowest cost of abatement will make the greatest contribution to meeting the target; others will absorb the tax

(b) There will be a stimulus to abatement technology not just to the standard levels but beyond as polluters seek to avoid the tax.

Against these benefits there are some obvious costs;

(a) detailed knowledge of production conditions and supply and demand elasticities are required in order to set the tax level. Given the information requirements iteration is inevitable. The costs of this uncertainty on firms' decisions could be considerable.

(b) With a standard, monitoring is necessary only to ensure that the standard is not breached. With pollution taxes all pollution must be monitored to determine liability for the tax. Typically the costs of monitoring rise as the level of pollution to be detected falls. With a number of substances the standards that can be set are limited by available detection technology eg some pesticide residues in water.

(c) Firms have a right to exceed the standard if they are prepared to pay the tax. This can be unacceptable.

The information and monitoring costs may in many cases be such as to make the taxation approach infeasible. If these costs are transferred to the polluter in accordance with PPP the costs on the polluters are likely to exceed the social costs of standards.

A suggested way of overcoming these problems is the issue of

tradeable permits. This technique avoids the problem of fixing the tax level (a) but it does not deal with the monitoring costs of (b); indeed it could add to those costs. Tradeable permits would work for the right to emit a luminous gas at night, but in many practical situations they are likely to be costly and inefficient.

An additional problem with tradeable permits is that control may need to be locationally specific while trade loses the control over location. This is the case with discharges to water courses where the impact of the discharge and hence the consequences for water quality targets depends on the location and timing of the discharge.

Green taxes face a similar set of problems but since they are levied on consumption raise also an additional one, that of equity. An example will illustrate. Consider a tax on petrol to reduce CO_2 emissions. The richer sections of the community who by and large do not pay for their motoring anyway will absorb the tax and those on the margins of affording motoring will bear the brunt of the reduction of emissions. This may be perceived as inequitable and carries with it two possible problems:

(i) a build-up of consumer resistance to environmental improvements which can be perceived as both excesssively expensive and as being unfairly imposed.

(ii) the 'Green Consumer syndrome'; a belief that one has only to buy green products and thus to pay the appropriate green taxes and the environmental crisis will be solved.

These two phenomena apply broadly to separate sections of the population but it should not be assumed that they cannot be manifested by the same individual in different contexts.

The question of equity is in fact at the heart of the environmental crisis. Sustainability entails firstly a shift of resources from current to future generations. For the current generation this means a shift of resources from consumption to investment: to develop cleaner technologies and environmentally safer goods and to conserve natural resources for the use of future generations. The crucial question then is how the sacrifice of current consumption is to be distributed among the current generation. Third world countries have already perceived that their citizens are at risk; they are in effect being told that their populations

cannot expect to enjoy the standards of living of the West because the planet cannot sustain such high consumption by so many people. They may not exploit their natural resources in the way that the West has exploited its resources since to do so will bring global disaster. They are rightly demanding that Western countries which consume the bulk of resources and produce the bulk of the pollution should bear the main burden of adjustment.

Within the West it is the wealthier portion of the population that consumes the major part of the natural resources. If the adjustments to overcome the environmental crisis are to be made it is important that the distribution of the sacrifices is accepted as equitable. This means that the incidence must fall more heavily on the rich than the poor. Market measures will not ensure this, rather they tend to operate within the existing structure of market power.

REFERENCES

(1) D Pearce, A Markandya and E Barbier, Blueprint for A Green Economy, Earthscan 1990.

(2) 2 Command 1200, This Common Inheritance, 1990

(3) N Watt, 'Patten's man turns to adverts in green campaign', Times, 29.9.90

(4) This subject may be found in expanded form in Bowers, J K (1990), Economics of the Environment: the Conservationists' Response to the Pearce Report, British Association of Nature Conservationists

ASSESSING THE ENVIRONMENT

CHALLENGES IN THE ASSESSMENT OF SOCIETAL RISK

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Introduction

The impetus provided by economies of scale has led to a steady expansion in the size and complexity of chemical and industrial plant during this century. The occurrence of a sequence of well publicised major accidents at such places as Flixborough in 1974, Seveso in 1976, Three Mile Island in 1979, Bhopal in 1984, Chernobyl in 1986 and Piper Alpha in 1988 has led to a greater public awareness of the existence of a finite risk of catastrophic accidents. Prior to this, it had been realised by the engineering community that the sheer pace of change associated with modern technology allowed less opportunity for learning by trial and error (UK Major Hazards Committee, 1979). Instead it was increasingly necessary to seek optimal design and operating procedures from the outset because, with their present-day size and throughput, there were many plants where a critical first mistake could result in disaster.

As a consequence, techniques of quantitative risk assessment (QRA) were developed for the purpose of predicting the overall risk arising from industrial activity and to identify areas where risk might reasonably be reduced. The procedure is illustrated in Figure 1. Thus, by 1971, if not sooner, it had been recognised that *absolute safety* could not be achieved in the design and operation of potentially hazardous plant. New plant were instead being designed to a self-imposed risk target (Farmer, 1981).

A crucial question, however, which continues to occupy the minds of many professionals working in the field, concerns the criteria which should be used to assess the acceptability or otherwise of the residual risk estimates for these low-probability high-consequence events (Gittus and Hayns, 1987). Sir Frank Layfield (1987), in his deliberations at the Sizewell Inquiry, was unable to reach any firm conclusion on this issue and considered the field to be beset by serious problems which required urgent elucidation. As a consequence, he invited the Health and Safety Executive to prepare a document on the tolerability of risk.

The purpose of this paper is to outline various approaches which have so far been suggested by the HSE and others for

enumerating and evaluating societal risk and to identify areas of debate. In the context of this paper, the term 'societal risk' refers to the harm which might be suffered by a community of individuals who are in some danger from an identified hazard.

There can be no doubt that the topic is of fundamental importance, both to industry in establishing the level of safety which is required of it, and society at large which bears the costs, and which ultimately must make decisions about the balancing of risks and needs in a world of finite resources.

Early Progress

In 1967, a paper by F.R. Farmer, on siting criteria for nuclear power plants, provided an early insight into the types of quantitative safety standards which might be adopted. Farmer recognised that the consequences of a hazard could not be described by a single number when it could give rise to accidents of different magnitudes. This led to the conclusion that there were two fundamentally important considerations in describing the risk to people posed by large (nuclear) plant, namely,

- the likely frequency of accidents
- the consequences of accidents

and this remains the basis of the most widely used approach to this day. Thus, a description of the risk associated with a particular hazard, on this basis, requires an estimate of the probability of each consequence, and the risk, in general, cannot be characterised by a single number (Farmer, 1981). The risk (R) is usually defined as the product of the frequency (or probability), F, and the consequence (C). Thus,

$$R = F \times C$$

Figure 2 shows Farmer's proposed criterion for the size and frequency of accidental releases of the radioactive isotope I-131 (I-131 was chosen since it is generally agreed that isotopes of iodine, and particularly I-131, carry a greater threat to health than other fission products which might be released in a reactor accident). A number of assumptions were made in determining the position of his boundary line. Firstly, it was assumed that the public would be more averse to a large release than a smaller one, even taking into account that large releases would be less frequent than small releases, and that the slope of the line, on a log-log scale, should therefore be greater than -1.0. A slope of -1.5 was

chosen, so as to reduce by three orders of magnitude the acceptable likelihood (frequency) of an event whose severity increases by two orders of magnitude. Farmer then postulated that a release of 1,000 curies (then estimated as capable of giving rise to about 3 fatal thyroid carcinomers in a typical population) might be considered acceptable for every thousand years of reactor operation. This value, together with the slope of the line, defines the main portion of the curve, which is then rounded off at low iodine release values to minimise the 'nuisance' caused by these more frequent emissions.

UK Approach to Industrial Risk Regulation

Risks associated with industrial activity are first assessed against three criteria (Health and Safety Executive, 1988):

- whether a given risk is so great or the outcome so unacceptable that it must be refused altogether

- whether the risk is, or has been made, so small (i.e. at *de minimis* level) that no further precaution is necessary

- if a risk falls between these two states, that it has been reduced to the lowest level practicable, bearing in mind the benefits arising from its acceptance and taking into account the costs of any further reduction.

The injunction laid down in British safety law is that any risk must be reduced *as far as reasonably practicable*, or, in other words, in accordance with the ALARP *(as low as reasonably practicable)* principle.

This approach is not without its critics. Sir Frank Layfield (1987), following the Public Inquiry into the acceptability of siting a PWR at Sizewell identified what he considered to be a number of weaknesses in the ALARP principle as applied to nuclear safety in the UK, many of which apply to industrial activity in general. These included:

- an absence of a clear definition of ALARP, the ensuing consequences being a potential misallocation of resources, misunderstanding and confusion

- the interpretation of 'gross disproportion'. (Legally, the controller of an industrial plant would have to undertake expenditure to reduce a risk unless the expense incurred were in gross disproportion to the risk reduction. For risks near to the unacceptable boundary, risk reduction would only be considered impracticable

if costs grossly exceeded benefits, whereas for risks near to the broadly acceptable level, a one to one ratio of cost to improvement would be more likely to be considered acceptable.) As reported by O'Riordan et al (1987), however, the ratio to be used is not clearly defined and can range from up to 3:1 to as high as 10:1, depending on the character of the risk, novelty of the technology, and uncertainty

- the tendency for an inexorable increase in safety standards without, necessarily, due regard for the justification. As a result, national resources could be misallocated between competing priorities.

Nonetheless, dividing risks into these three broad zones undoubtedly provides some degree of structure. Were it possible to use this framework and define the level of risk separating these three regions, an enormously useful tool would have been provided.

In 1976 the Royal Commission on Environmental Pollution examined the Farmer approach. They drew attention to the observation that risks to individual members of the public of 1 in 1,000 per year would be considered unacceptable, risks of 1 in 10,000 per year would be considered to warrant expenditure on risk reduction, and that risks below one in a million per year would usually be accepted without concern. The Royal Society Study Group came to similar conclusions in 1983 about the levels of individual risk which the public appeared to tolerate, though suggesting that the level below which further control might be considered unjustified could be as low as 1 in a 10 million per year in some circumstances.

The Royal Society Study Group went on to say that for high-consequence hazards, it would not be sufficient to equate, say, a 1 in 10,000 annual chance of killing 10,000 people to a hazard resulting in one death per year, since the response of society to the two kinds of event would be different. They therefore endorsed Farmer's view that a frequency curve relating the magnitude of the consequences of an event to the expected probability of that event would be appropriate.

The Development of F/N Curves

The most widely encountered expression of societal risk is as an F/N curve, also known as cumulative distribution function. This simply plots the frequency, F, of events exceeding a given magnitude, N. Although many kinds of detriment may result from a disaster, F/N curves have traditionally been largely confined to consideration of immediate or early

deaths. The most sophisticated societal risk criteria of this kind published to date are attributable to Versteeg and Visser (1987) in Holland. For individual risk, both a limit value and a *de minimis* value have been developed as boundary values. For new stationary hazardous sources an individual risk limit of 10^{-6} per annum (based on the consideration that an industrial activity should not increase the mortality risk of a 10 to 15-year old child by more than 1%), and a *de minimis* value of 10^{-8} per annum have been chosen. In the area between these two boundary values the ALARA (as low as reasonably achievable - similar to ALARP) (Harbinson and Winyard, 1987) principle is applied.

A limit value and *de minimis* level have also been defined for societal risks. These boundary levels are defined by two F/N curves, each in the form of a straight line on a log-log scale (Figure 3), where F is the frequency of an event with N early fatalities. Examination of the curves in Figure 3 reveals a slope of -2. In other words, a good deal of high consequence aversion has been incorporated. The base point used by the authors is the frequency of accidents killing 10 or more people, which is taken as 10^{-5} per annum and 10^{-7} per annum for the upper and lower levels.

There is no doubt that these requirements are stringent. For example, Figure 4 shows levels of risk, based on QRA calculations, associated with the Canvey Island complex (after improvements) and other facilities, which have been judged tolerable. Figure 5 shows the historical record in the UK of the chemical and petrochemical industries expressed as F/N diagrams based on actual accidents occurring during the period 1966-86 (Fernandes-Russell, 1988). Layfield (1987) also found aspects of the Dutch criteria unacceptable, and doubts have been expressed as to their realism (UKAEA, 1990).

In response to these concerns, and Layfield's more general request for a document on the tolerability of risk, the Health and Safety Executive has published a series of reports (HSE, 1988; 1989a; 1989b) outlining its own position, particularly in regard to nuclear safety which was Layfield's primary concern at the Sizewell Inquiry.

In summary, HSE reported (HSE, 1988) that a risk of death of 1 in 1,000 per annum is about the most that is ordinarily accepted under modern conditions for individual workers in the UK, and took this as the dividing line between what is just tolerable and what is intolerable. It was then suggested that the maximum tolerable level of risk from any large-scale industrial hazard for members of the public should not be greater than one tenth of this, i.e. 1 in 10,000 per annum. Similarly, 1 in 10^6 per annum was identified as the level of

risk which, so long as precautions were maintained, might be broadly acceptable to the public, and which would not require further expensive improvements in safety standards.

So far as societal risk from nuclear power was concerned, the HSE first defined a 'major civil nuclear accident' as one which gave rise to an uncontrolled release of a size capable of giving doses of 100 mSv at 3 km, which pessimistically might cause the eventual deaths from cancer of about 100 people in the UK. In order to gauge what might be the tolerable frequency of such events, comparisons were drawn with two catastrophic risks in the non-nuclear field. First, it was noted that risks to the public at Canvey Island had been reduced to about 1 in 5,000 per annum against a major accident capable of causing more than 1,500 casualties. Second, it was noted that the design specification for the Thames Barrier required that the chances of its being overtopped be less than 1 in 1,000 per annum, with an estimated consequence of between 100 and 1,000 fatalities. From this it was deduced that where there is little choice in whether or not to accept a major societal risk, that risk should be less than 1 in 1,000 per annum and if possible less than 1 in 5,000 per annum. However, in the case of nuclear risks HSE drew attention to the greater degree of public anxiety, and the possible economic consequences of a significant release of radioactivity, and proposed more stringent criteria. Thus, it concluded that a figure that might be accepted as tolerable for the frequency of a considerable uncontrolled release *anywhere in the UK* (i.e. not just from a single reactor) might be about 1 in 10,000 per annum, where the *eventual* magnitude of the consequence was the death from cancer of about 100 people. Thus, the HSE incorporated a considerable 'aversion factor' so far as the nuclear hazard is concerned, largely on the basis that the public appears to be substantially less tolerant of nuclear than conventional hazards.

So far as F/N diagrams are concerned, Figure 4 shows the $N=100$, $F=10^{-4}$ point, which is rapidly becoming regarded as the HSE maximum tolerability point for nuclear risks. To this has been added a line of slope -1 which the HSE considers is the *least* which the public might require for a larger consequence event (HSE, 1989a).

From the above discussion it would seem that the HSE have distinguished the intolerable/maximum tolerable and *de minimis* levels for individual risk to members of the public. For societal (and occupational) risk, however, the intolerable/maximum tolerable boundary has been defined, but not the *de minimis* level.

The Advisory Committee on Major Hazards (ACMH, 1976), suggested 1 in 10,000 per annum as the maximum tolerable annual frequency for a serious accident for any *one* major conventional plant, where the consequence might be inferred as the deaths of 10 or more people on or off site (HSE, 1989a).

Risk Aversion

The concept of *risk aversion* was encountered in the preceding sections. Risk averse individuals are generally thought of as those who would exhibit a preference for allocating resources to reduce the risk of large accidents leading to multiple fatalities, rather than to a number of smaller accidents, *even where the latter course would result in more lives saved overall.* As remarked, this concept was incorporated both in the Farmer criterion (Figure 2), and those described by Versteeg and Visser (Figure 3).

There is much debate, however, over the degree to which risk aversion should be incorporated into safety criteria or even whether it should be incorporated at all. Many economists regard risk-averse preferences as, at best, irrational or misinformed, and at worst morally repugnant, since the implication is that lives are valued differently whether lost collectively or individually (Linnerooth, 1990). Zeckhauser and Viscusi (1990), for example, consider that incorporation of risk aversion into risk management practices has introduced serious flaws into the way in which society deals with risk, and that *risk neutrality* instead should be pursued. That is to say, all lives should be valued equally, since this is the most effective means of promoting risk reduction objectives. In practice, examination of historical risk management decisions has shown this to be far from the case. Valuations of a statistical life vary over many orders of magnitude from a few hundred pounds to a few hundreds of million pounds (Fernandes-Russell et al, 1988).

This approach, however, also has its detractors. Schrader-Frechette (1985) has argued that it is perfectly reasonable to be more averse to low probability-high consequence events even though economic (utility) theory does not differentiate between these and high probability-low consequence accidents. One justification for this, cited by Schrader-Frechette, might be the evidence of higher psychological trauma associated with the imposition of a public risk as opposed to that associated with the choice of a private risk with the same probability (Pahner, 1975). Linnerooth has likewise drawn attention to the fact that risk aversion is a multi-dimensional concept and should not be treated in an overly simplistic way. In her paper

(Linnerooth, 1990) she identifies two of these dimensions as:

- aversion to multiple fatalities from a common cause
- aversion to collective fatalities where there is little control.

Both these authors and many others besides, point out in addition that public tolerability of risk is far from related to just the "kill size". The HSE (1989a) has identified forty-one other factors on the basis of its own experience. These factors seem to group into a taxonomy whose principal headings are as follows:

- the hazard, the consequential risks and the consequential benefits
- the nature, purpose and limitations of the assessment
- factors of economic, national and political importance
- public attitudes including confidence.

Studies in several disciplines, including sociology, political science, anthropology and psychology, have shown that the concept of risk means different things to different people. When experts judge risk, their responses correlate highly with scientific estimates of annual fatalities. On the other hand, lay people's assessment of risk appears to be "richer", in that it includes other dimensions such as catastrophic potential, threats to future generations, and voluntariness (Slovic, 1987). It would now appear that differences of opinion between experts and the public are not entirely attributable, as has sometimes been supposed, to a failure of comprehension or an inability to understand probabilities on the part of the public. In other words, there is wisdom as well as error in public attitudes and perceptions (Slovic, 1987).

Thus, it could be argued that the additional safety requirement which results from the incorporation of risk aversion considerations goes some way towards meeting these other concerns, *providing* there is a reasonable correlation between the number of fatalities in a catastrophe and its wider ramifications. This condition, however, is far from satisfied in reality. As one example, the accident at Three Mile Island is said to have imposed costs in excess of $500 billion on society, while leading to no immediate deaths and perhaps no delayed deaths either, though it did cause temporary evacuation and much trauma and anxiety.

Slovic et al (1984) are also highly critical of all proposals

for modelling the impacts of multiple-fatality accidents which have been based upon some form of utility function asserting that the societal cost (or disutility) of N lives lost in a single accident is a function of N^{α} where α is a constant. There are three general forms of these models according to whether $\alpha=1$ (risk neutrality), $\alpha>1$ (risk aversion), or $\alpha<1$ (risk proneness). Their view is that social response to multiple-fatality accidents does not in fact reflect risk aversion at all, but rather that accidents of this kind are perceived as unknown and consequently unbounded. In other words, it is not that $\alpha>1$ for certain types of industry, but that the potential value of N is believed to be very large.

Beyond the F/N Diagram

Various attempts have been made to incorporate further dimensions of harm besides immediate fatalities into risk assessments as a means of assessing the severity of disasters more comprehensively. Marshall (1988), in a recent comparison of Chernobyl with other major industrial disasters, suggested nine categories of harm as follows:

- immediate deaths
- delayed deaths
- disabling injury
- non-disabling injury
- individual or societal shock
- long-term consequences for mental health
- disruption of people's way of life
- environmental damage
- property damage and other financial loss

This, however, often leads to further questions concerning the comparability and commensurability of different types of harm. Pochin (1977) addressed several aspects of this problem in his early paper on the development of an *index of harm*. In this work he was primarily concerned with the question of how one might compare the total harm that may be caused by radiation, both in those exposed and in their descendants, with the total harm involved in other occupations, whether by fatal or minor injury, occupational disease, or by the effects of mutagens in the work place. Pochin noted that death, although commonly used as an index of the comparative safety or harm of different industries, had numerous limitations. Clearly, it omitted consideration of non-fatal injuries and diseases. It also failed to discriminate between immediate deaths and late deaths arising from various forms of malignant disease, and between the length of life lost in these two circumstances. For example, Pochin estimated that occupational accidental fatalities involved an average loss of about 30 years of life, whereas radiation-induced fatal

malignancies accounted for a loss of 10 to 15 years. By further development of this line of argument, Pochin was able to arrive at a unified index of harm expressed in man-years per year per 1000 employees, which incorporated the effects of accidental fatalities, non-fatal accidents, industrial diseases, radiation-induced somatic and genetic effects, and effects during pregnancies. Since this approach was based on time lost, it was unable to account in any way for human anxieties and detriments associated with what is now commonly known as the *pain, grief and suffering* element. The work is, nonetheless, of great interest.

More recently Clement (1989) has also tackled the question of comparability of different types of harm in the context of major disasters, while introducing the idea of a 'risk profile' of a disaster to characterise the numbers of people affected in different ways. Clement described effects upon individuals under five headings:

- early deaths
- late deaths
- serious incapacity
- forced permanent evacuation
- serious birth defects

These could be amalgamated if desired by constructing the sum

$$N = \sum_{i=1}^{5} a_i N_i$$

where a_i are weighting factors to compare each of the above risks with that of early death, for which $a_1=1$. Techniques are available for determining the other weighting factors. a_2, could be calculated on the basis of loss of life expectancy, a_3 by the use of QALY (quality adjusted life years) factors (Williams, 1985), and a_5 by a combination of the two. A value of a_4 is perhaps more difficult to arrive at; Clement suggests a value of 0.1.

Disasters such as Chernobyl and Seveso also carry huge financial costs for society. Clement suggests that were it considered necessary to have a single measure, a total cost, T, might be defined as:

$$T = C + bN$$

where C is the cost of overt societal measures, such as value of lost plant, clean-up operations, health care, lost output, relocation, etc., and b is a value assigned to a human life akin to that used for the purpose of safety investment

decisions (Fernandes-Russell et al, 1988).

Uncertainty and Dread

Fischhoff et al (1984), in deriving a risk index, introduce *public concern* as a further consequence of risk, despite its not having an obvious physical or physiological measure. Studies of lay risk perceptions (Fischhoff et al, 1978; Slovic et al, 1984) have shown that concern about the risks of technologies can be predicted quite well by two subjective dimensions of risk, reflecting the degree to which the risk is *unknown*, and the degree to which it invokes a feeling of *dread* (Figures 6 and 7).

In an analysis of the comparative risks of energy technologies Fischhoff et al (1984) include within their risk index five attributes, namely: public death risk, worker death risk, morbidity (i.e. all non-fatal injuries, illnesses and genetic damage), concern for the unknown, and dread. They also assume, for the purpose of the analysis, that the public is risk neutral. Each of the five attributes was scored on a scale zero to 100 for each energy technology. For the first two attributes scores of 100 were arbitrarily defined as equivalent to 10 public or 10 occupational deaths per GWy of electricity generated or saved. Similarly, 60,000 person-days of incapacity merited a score of 100 on the third attribute. Table 1 shows the characteristics which would give a technology score of zero or 100 on attribute 4 (unknown risk) and 5 (dread risk).

Finally, weighting factors were assigned to each attribute, and a composite score, in the form of a single number, arrived at for each energy industry considered. Various weighting systems were tried since these clearly reflect value judgements, and cannot be uniquely determined. It was found that the riskiness of coal, small-scale windpower and conservation varied little with the different weighting systems employed. However, nuclear power varied greatly, being best or worst depending upon the system used.

Despite the many acknowledged restrictions inherent within their analysis, it is apparent that the relative riskiness of different technologies is sensitive to how the risk is *defined*, and the *value systems* used by individuals in achieving an overall assessment.

Cultural Theory

Rayner and Cantor (1987) have thrown down the gauntlet to

several of the dominant assumptions of current approaches to societal risk management. They assert that while assessments of probabilities and consequences of undesired outcomes are essential for making engineering decisions about competing designs or alternative materials, they are largely irrelevant to societal technology choices. In particular, they challenge the usefulness of the mathematical definition of risk

$$R = F \times C$$

suggesting instead that popular understanding of risk does not depend upon probabilities, but may rest exclusively on consequence. They point out that the problem of public perception of risk is often framed by experts in terms of differential perceptions of probabilities, but that in reality the choices between those probabilities are incomprehensible, and perhaps irrelevant, to most of the public, and to a lot of policymakers as well.

Cultural theory as a whole basically rejects the notion that differential risk perceptions are in any way crucial components of conflicts over societal risk. Instead, modern theories of social anthropology (Douglas and Wildavsky, 1982; Schwarz and Thompson, 1990) attribute the conflicts to alternative *world views* held by different social groups, each of which generates its own, legitimate, rationality.

A simplifying assumption of this theory is that what at first sight might appear to be an infinite array of social interactions, can in fact be sorted and classified into a few grand classes (Douglas, 1982). In fact, cultural theories impossibility theorem reduces this to just four viable solutions, constituting four rival and incommensurate ways of life. These are known as: hierarchy, individualism, egalitarianism and fatalism (Thompson et al, 1990). Ironically, each one's problem is largely constructed by the other three's solutions! In turn, each group has an alternative perspective on the robustness of the environment. It has been suggested that these can be encapsulated in what is known as the *myths of nature*. These are, respectively, nature perverse/tolerant, nature benign, nature ephemeral and nature capricious (Figure 8).

The anthropologists suggest that these world views are rooted more in social contexts than in individual perceptions of probability. Each group is perfectly rational, given its convictions about the state of the world. The situation is therefore one of *plural rationalities* (Schwarz and Thompson, 1990) which are contingent upon the cultural biases of each group. This leads inevitably to the conclusion that there

is no such thing as a rationality which is truly independent of social or organisational context.

Concluding Remarks

As noted in the Introduction to this paper, the purpose has not been to try to formulate grand solutions to the problem of societal risk, but rather the much more limited objective of identifying strands in the current debate. This is not because progress is undesirable. Indeed, expenditure by society on risk reduction now exerts a significant, if largely hidden, toll on lifestyles, both in terms of pounds sterling forfeited, and forgone pleasures. To quote Zeckhauser and Viscusi (1990):

> "Economic valuations are distorted by misweighting of risks .... Because of this imbalance, we pay more dollars for our products and end up with greater risks to our lives."

One local decision, which outwardly appears to fall into this category, relates to measures to reduce public exposure to radio- active discharges from Sellafield. According to Berry et al (1990):

> ".... it is salutary to note that in strict financial terms the cost has been some £250M to prevent a statistical possibility of 1 or 2 cancer deaths over the next ten thousand years."

This is not to imply that public concerns should go unheeded. Even in the case of Zeckhauser and Viscusi (1990), who are clearly perturbed by the impact of citizens' "misperceptions" on the decision-making processes, there is a clear recognition that,

> "In a democratic society one should hesitate to override the legitimate preferences of segments of the population, taking care not to dismiss diversity of taste as mere nonrational choice. Where there is broad consensus on a rational course of action, however, and either the cost of providing information is high or individuals cannot process the information adequately, mandatory requirements may be preferable to risk information efforts."

Although their analysis, couched in these terms, would be far from universally accepted, many of those whose work has been described here would, even from their disparate standpoints,

acknowledge that much expenditure to reduce risk is misdirected. The reasons, however, for this misdirection, would be perceived differently. Some might attribute it to a failure to value lives equally across sectors, while others might attribute it to an ill-informed public, and yet others to a failure of decisionmakers to countenance the possibility of plural notions of rationality.

Rayner and Cantor (1987) propose that

> "What is needed is a polytheistic definition that encompasses both societal concerns about equity at the risk-management end of the conceptual chain and engineering-type concerns about probability and magnitude at the technical end."

There are, of course, signs of shifts towards a greater awareness of alternative perspectives. Thus, the studies by Clement (1989) and Marshall (1988) which adjust for risk context by adding factors for the social disruption due to catastrophes, psychological trauma, and the age of victims would, following the arguments of Linnerooth (1990), reflect a more forgiving view of nature characteristic of two of the four groups, the individualist and the hierarchist, identified by social anthropologists.

Acknowledgements

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REFERENCES

Advisory Committee on Major Hazards (1976) First report of the Advisory Committee on Major Hazards. HMSO, London.

Berry, R.J., Coulston, D.J. and Coates, R. (1990) Dose minimisation and optimisation - experience in the UK nuclear fuel cycle. ALARA II Conference, Institution of Nuclear Engineers, London, 20 September.

Clement, C.F. (1989) The characteristics of risks of major disasters. Proc. R. Soc. Lond., **A424**, 439-454.

Cox, R.A. and Slater, D.H. (1984) State-of-the-art of risk assessment of chemical plants in Europe. In: Low-probability high-consequence risk analsyis, edited by Waller, R.A. and Covello, V.T., Plenum Press, 257-283.

Douglas, M. (1982) Essays in the sociology of perception. Routledge and Keegan Paul.

Douglas, M. and Wildavsky, A.B. (1982) Risk and culture. University of California press.

Farmer, F.R. (1967) Siting criteria - a new approach. In: Containment and siting of nuclear power plants. Proc. Symposium, International Atomic Energy Agency, Vienna, 303-329.

Farmer, F.R. (1981) Quantification of physical and engineering risks. Proc. Roy. Soc. Lond., **A376**, 103-119.

Fernandes-Russell, D. (1988) Societal risk estimates from historical data for UK and Worldwide events. UEA Environmental Risk Assessment Unit, Research Report No. 3.

Fernandes-Russell, D., Bentham, G., Haynes, R., Kemp, R. and Roberts, L. (1988) The economic valuation of statistical life from safety assessment. UEA Environmental Risk Assessment Unit, Research Report No. 5.

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S and Combs, B. (1978) How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Sciences, **8**, 127-152.

Fischhoff, B., Watson, S.R. and Hope, C. (1984) Defining risk. Policy Sciences, **17**, 123-139.

Gittus, J.H. and Hayns, M.R. Risk assessment. Proc. Roy. Soc. Edinburgh, **92B**, 139-154.

Harbinson, S.A. and Winyard, R.A. (1987) An HMNII view on quantitative optimization techniques in regulatory control. In: ALARA - principles, practice and consequences. ed. Lakey, J.R.A. and Lewins, J.D. Adam Hilger.

Health & Safety Executive (1988) The tolerability of risks from nuclear power stations. HMSO, London.

Health & Safety Executive (1989a) Quantified risk assessment: its input into decision-making. HMSO, London.

Health & Safety Executive (1989b) Risk criteria for land-use planning in the vicinity of major hazards. HMSO, London.

Layfield, F. (1987) Sizewell B Public Inquiry Report. HMSO, London.

Linnerooth, J. (1990) Risk neutrality or risk aversion? The economist's perspective. Paper to meeting on 'Risk and Rationality'. University College London, 7-8 September.

Marshall, V.C. (1988) Chernobyl - was it the worst accident? Loss Prevention Bulletin, June issue, 1-14.

O'Riordan, T., Kemp, R. and Purdue, H.M. (1987) On weighing gains and investments at the margin of risk regulation. Risk Analysis, 7, 361-369.

Pahner, P.D. (1975) The psychological displacement of anxiety: an application to nuclear energy. In: D. Okrent, Risk-benefit methodology and application, UCLA School of Engineering and Applied Science.

Pochin, E. (1977) Problems involved in developing an index of harm. Annals of the International Commission on Radiological Protection, 1, No.4, ICRP Publication No. 27.

Rayner, S. and Cantor, R. (1987) How fair is safe enough? The cultural approach to societal technology choice. Risk Analysis, 7, 3-9.

Royal Commission on Environmental Pollution (1976) Nuclear power and the environment, 6th report. HMSO, London.

Royal Society (1983) Risk assessment. Study Group report, published by the Royal Society, 6 Carlton House Terrace, London, SW1Y 5AG.

Schrader-Frechette, K.S. (1985) Risk analysis and scientific method. D. Reidel Publishing Company.

Schwarz, M. and Thompson, M. (1990) Divided we stand: redefining politics, technology and social choice. Harvester Wheatsheaf, London.

Slovic, P. (1987) Perception of Risk. Science, **236**, 280-285.

Slovic, P., Lichtenstein, S. and Fischhoff, B. (1984) Modelling the societal impact of fatal accidents. Management Science, **30**, 464-474.

Thompson, M., Ellis, R. and Wildavsky, A. (1990) Cultural theory. Westview Press.

United Kingdom Atomic Energy Authority (1990) Social risks: a review of the technical basis for the management of risks to society from potential major accidents. Report by UKAEA Working Group.

UK Major Hazards Committee (1979) Second report of Advisory Committee on Major Hazards. HMSO, London.

Versteeg, M.F. and Visser, B.J. (1987) A PRA-guide for the Netherlands; a consequence of the Dutch policy on risk management applied to nuclear energy. Proceedings of probabilistic safety assessment and risk management conference, Zurich, 1058-1065.

Williams, A. (1985) Economics of coronary artery bypass grafting. Br. Med. J., **291**, 326-329.

Zeckhauser, R. and Viscusi, W.K. (1990) Risk within reason. Science, **248**, 559-564.

Attribute	Score of 0 implies risk has these properties	Score of 100 implies risk has these properties
4. Unknown risk	Observable	Not observable
	Known to exposed	Unknown to exposed
	Effect immediate	Effect delayed
	Old	New
	Known to science	Unknown to science
5. Dread risk	Controllable	Uncontrollable
	Not dread	Dread
	Not global catastrophic	Global catastrophic
	Consequences fatal	Consequences not fatal
	Equitable	Not equitable
	Individual	Catastrophic
	Low future risk	High future risk
	Easily reduced	Not easily reduced
	Decreasing	Increasing
	Voluntary	Involuntary
	Doesn't affect me	Affects me

Table 1: The components of attributes 4 and 5 (Fischhoff et al, 1984)

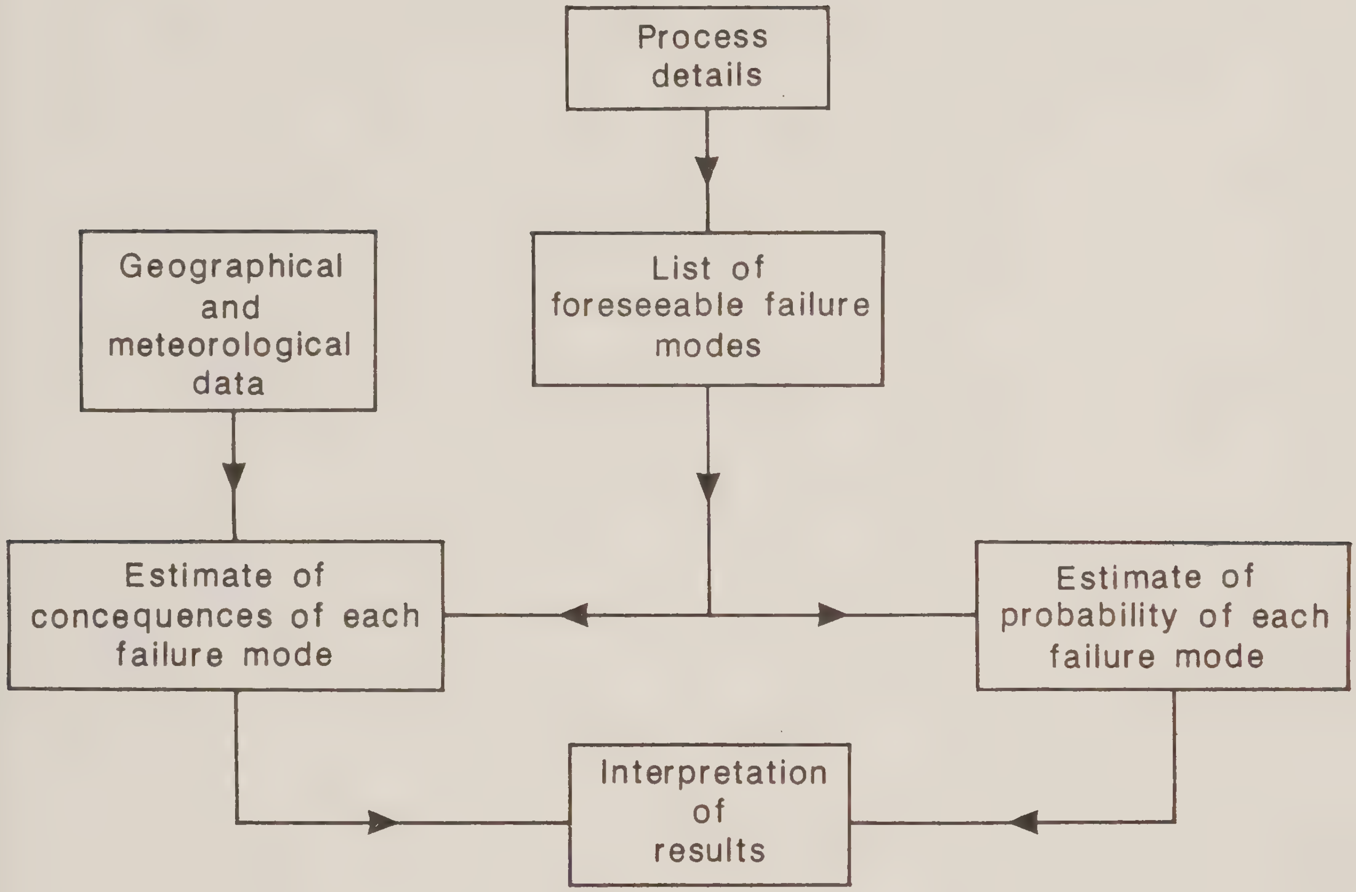

Figure 1: Stages in quantitative risk analysis of an industrial process (based on Cox and Slater, 1984).

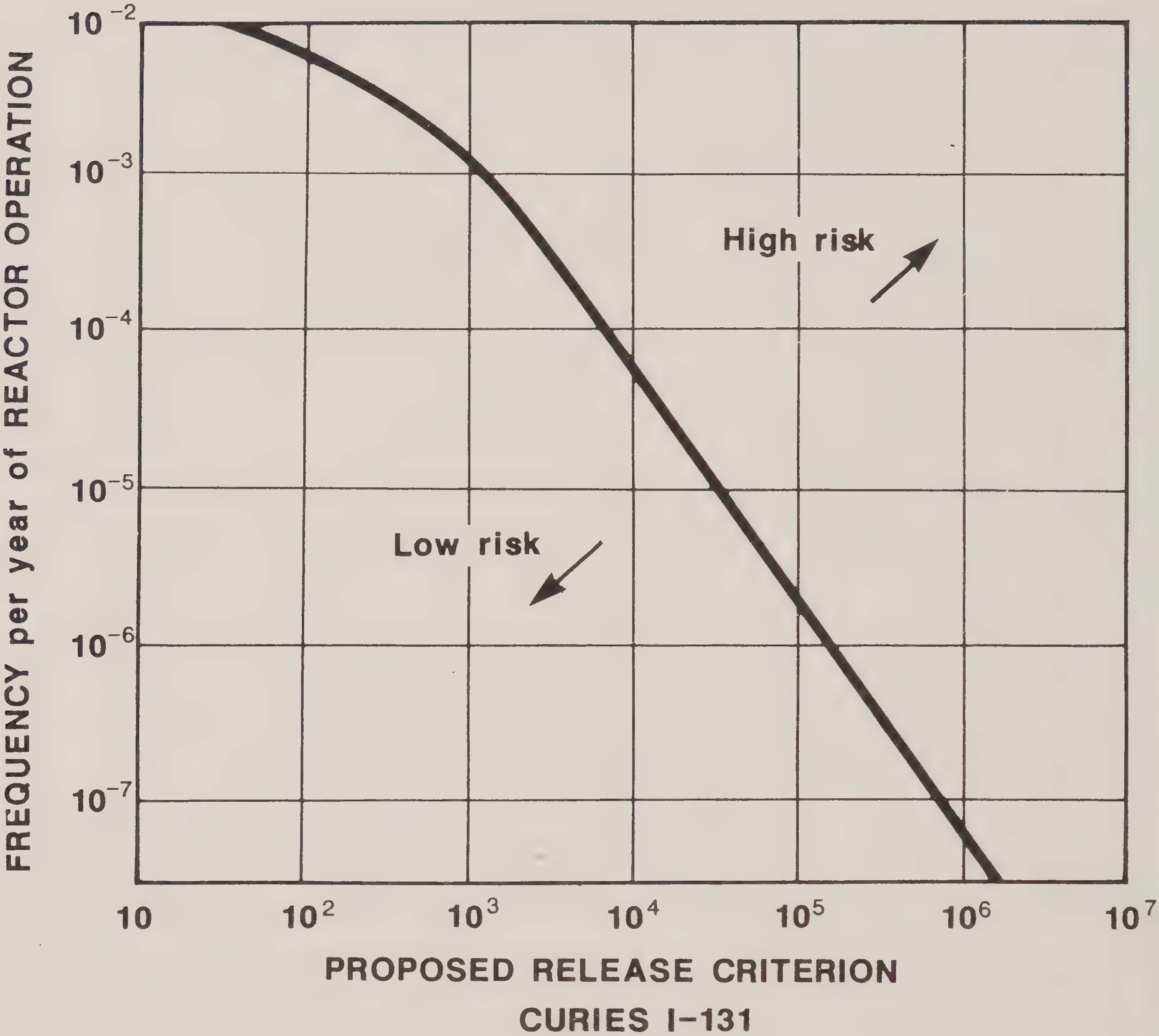

Figure 2: Proposed accidental release criterion for I-131 (Farmer, 1967).

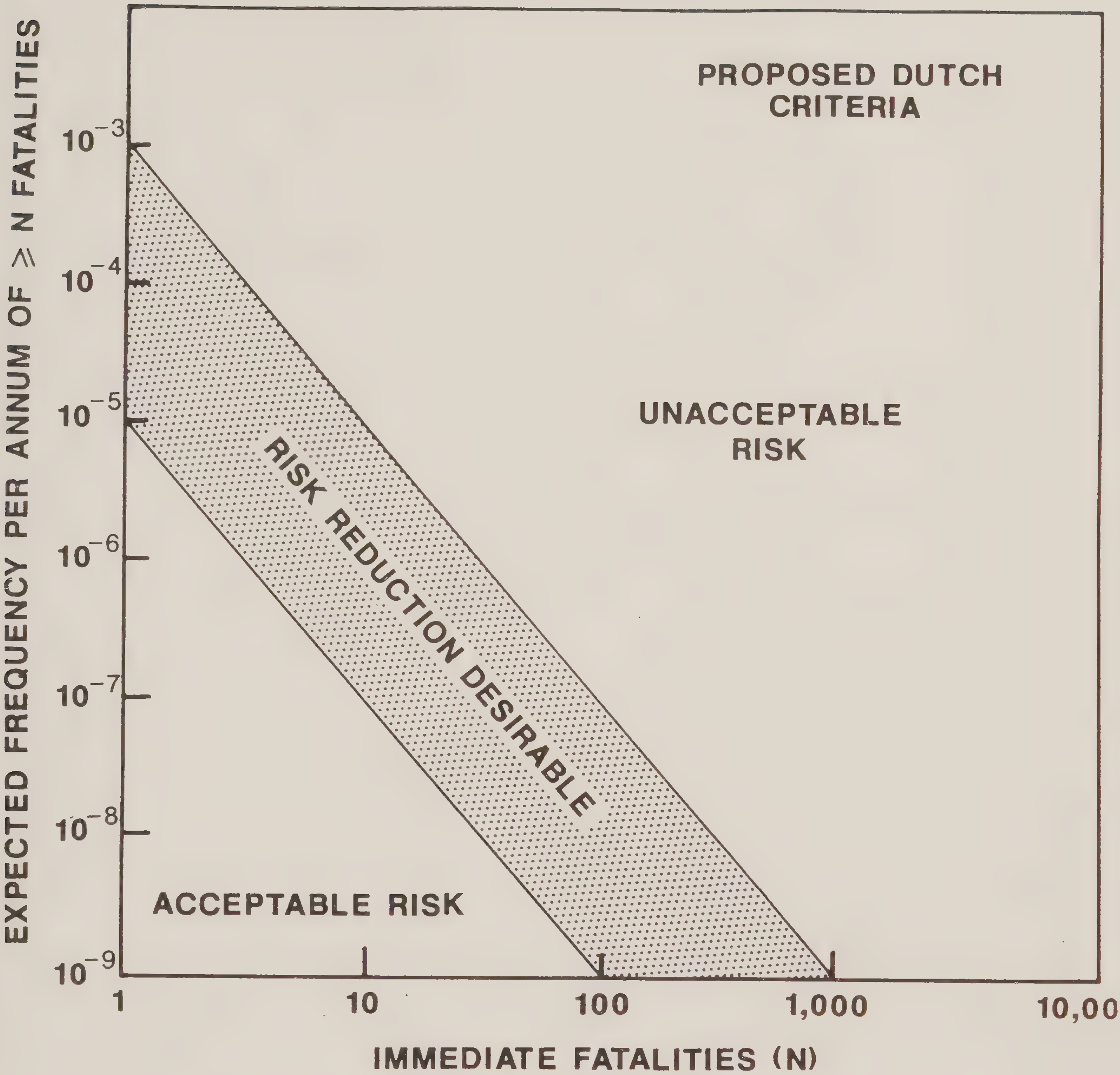

Figure 3: Dutch societal risk criteria as proposed by Versteeg and Visser (1987).

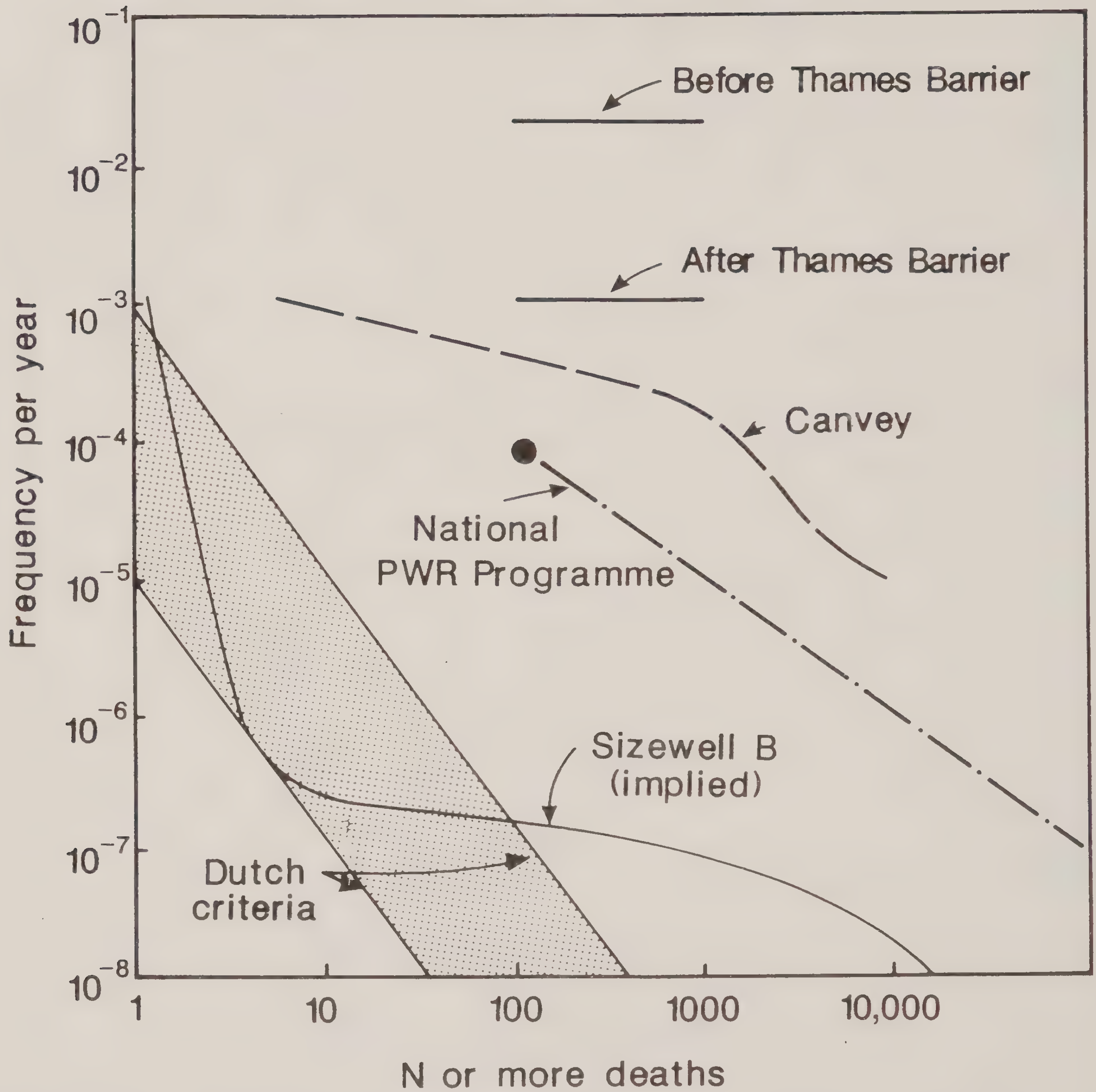

Figure 4: F/N diagram comparing societal risks as determined by engineering calculations and modelling for different existing and proposed installations. The line for the national PWR programme originates from the HSE (1989a) maximum tolerable point (N = 100, F = 10^T-4^T/a), and differs from the other curves in that it applies to a whole programme of reactors, perhaps as many as twenty.

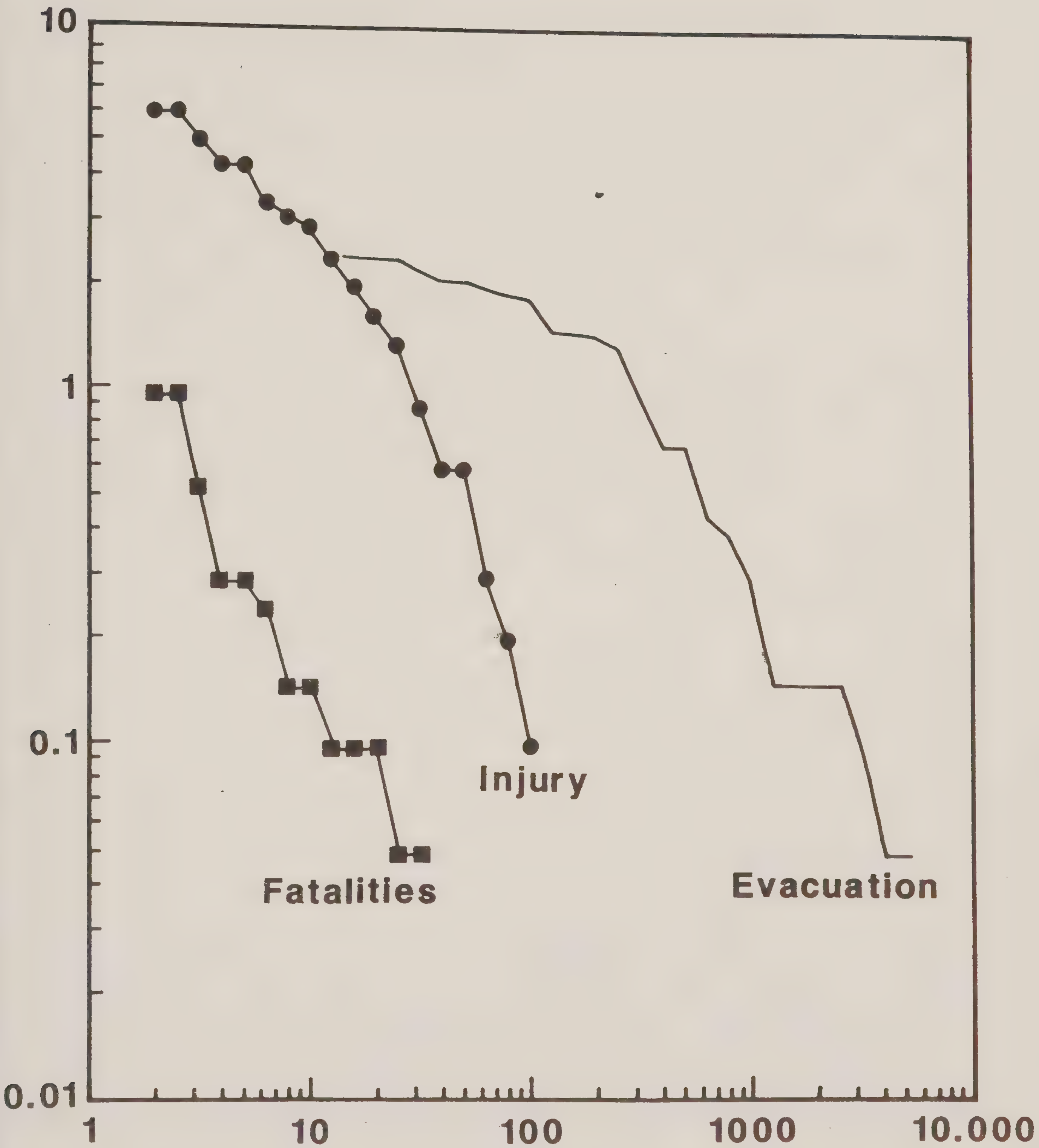

Figure 5: Frequency and consequences of accidents in the UK chemical and petrochemical industries from 1966 to 1986 (Fernandes-Russell, 1988).

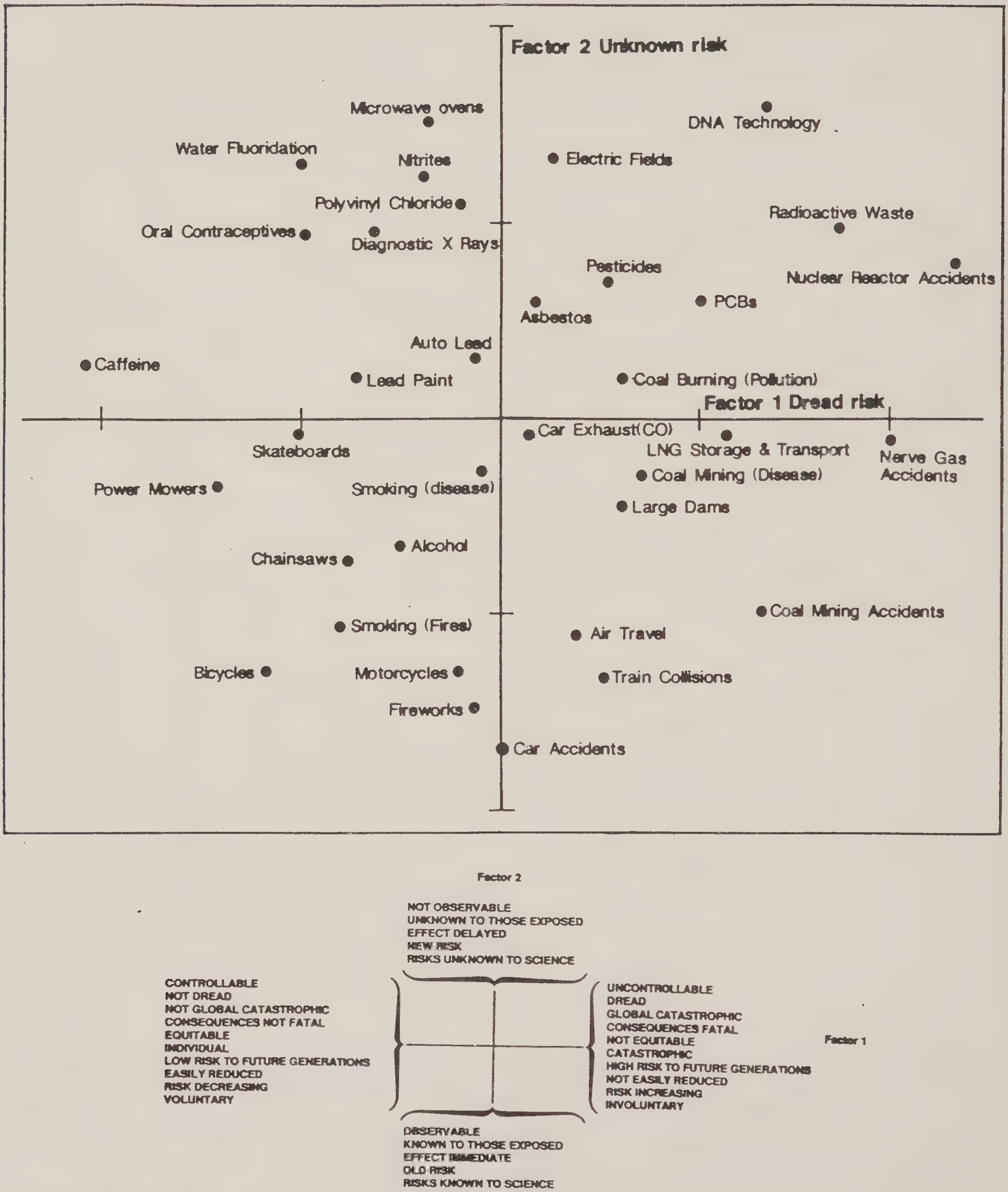

Figure 6: Simplified version of a diagram by Slovic et al (1984) indicating how the public perceive the risks of various technologies in terms of the factors "unknown risk" and "dread".

Figure 7: Relation between "signal potential" and risk characterisation for thirty hazardous activities. The larger the size of the point, the greater the degree to which an accident involving that hazard was judged as a warning to society (Slovic et al, 1984).

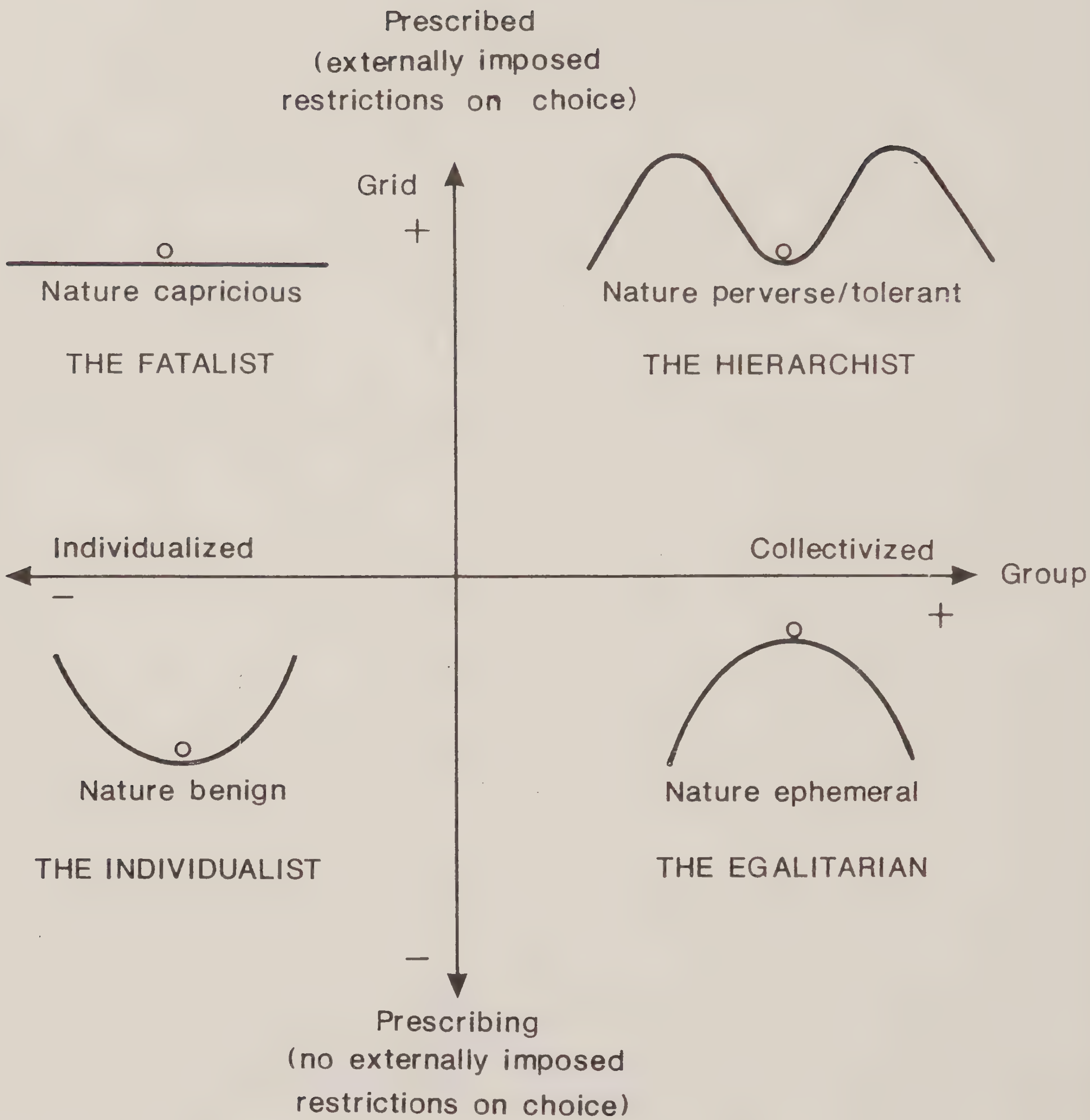

Figure 8: The four rationalities and their corresponding myths of nature as proposed by social anthropologists (Douglas, 1982; Schwartz and Thompson, 1990).

ASSESSING THE ENVIRONMENT

ENVIRONMENTAL AUDITS FOR LOCAL AUTHORITIES

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Two influential documents were published last year - *Action for the Future, Priorities for the Environment*, by the Association of Metropolitan Authorities, and *The Environmental Charter for Local Government - Practical Recommendations*, by Friends of the Earth. Both have helped focus the minds of authorities on environmental issues. But how should local authorities respond? This is the question many are now trying to grapple with. Both documents recommend that local authorities carry out environmental audits. Such audits have a key role to play in the development and implementation of an environmental policy and many authorities are using an audit as a starting point. An Environmental Audit will:

1. provide an authority with baseline information on the quality of the local environment, allowing the principal environmental issues to be identified;

2. review existing environmental policies of the authority and how they are being implemented;

3. examine current practices of the authority;

4. highlight successful environmental policies and practices;

5. identify opportunities for improvements in policies and practices, which can form the basis for an environmental action plan.

Just as with a financial audit, an environmental audit will look at what is happening at the time of the audit. The audit will assemble existing information, not generate new information. Thus environmental monitoring should not be seen as part of the audit, but may be an outcome of the audit. Again, as with financial audits, the environmental audit should be seen as a regular review, the frequency of which will depend on the nature of the authority and its local environment. A repeat audit every 2-3 years might be appropriate. The first audit will be particularly important and is likely to involve more time and resources than subsequent audits. The more thorough the first audit, the easier it will be to develop environmental policies and action programmes.

Who should carry out the audit?

There are two key words that should be borne in mind when answering this question. The first is *independent* and the second is *team*. To be most effective, the audit should be carried out by an independent team, which can be drawn up in-house from another part of the organisation, or involve the use of an external consultancy. Whichever approach is used, there will be a strong involvement of in-house staff in assisting the audit team, by providing them with information necessary for their review.

The importance of independence should be fairly self-evident, just as it is with financial audit. It is generally easier for an outsider to gain an overview of operations and to apply a critical eye, although the insider will understand the details of what is going on.

The involvement of a team in carrying out the audit is important because of the many different aspects of the local authority's performance that are being examined. It needs expertise in each of these areas to carry out an effective audit - an ecologist is not the best person to review energy conservation issues.

Who should initiate the environmental audit?

A commitment from the very top is necessary to ensure the success of the environmental audit. With this commitment, the rest of the organisation realises that environmental issues are being paid more than lip service. It also gives the audit team the necessary authority to ensure that it receives the co-operation of all staff. The Chief Executive is likely, therefore, to have a role to play in commissioning the environmental audit, with the Policy and Resources Committee or its equivalent playing a pivotal role.

Communications will play an important role in generating the commitment of senior management in the various departments to the development of policies and practices designed to protect and imrpove the local environment. This same commitment will be required to ensure the success of the environmental audit. Even if the audit is carried out by outside consultants, in-house staff will be required to spend a fair amount of time providing assistance to the audit team, and this needs to be recognised by senior management.

What is the scope of an environmental audit?

Environmental audits for local authorities are a new concept, and there is no clear definition of what an audit is. A

consensus is, however, developing that the audit should cover three general areas, although there is clear overlap between them:

1. state-of-the-environment in the authority's area;

2. policies established by the authority;

3. practices of the authority itself.

There has been a tendency in the early audits to focus on the first item - the "state-of-the-environment". This, though, can only be considered to be part of a full environmental audit. The advantage to the authority of including the second two areas in the audit is that it has a direct influence over these. The same is not necessarily true of some of the items included in the state-of-the-environment review where, for instance, water quality is reviewed, but the local authority has no direct control.

State-of-the-environment

The state-of-the-environment review provides information on existing environmental conditions. It involves collecting available data on air quality, water quality, land contamination, ecology and noise. These data are assessed in relation to available criteria, for instance air quality guidelines and standards. The review should also identify major sources of pollution problems. This part of the audit will allow priority areas for action to be identified.

Policies

Policies are the backbone of local authority activities and it is therefore important to establish whether they are effectively taking environmental issues into account. The audit should identify all council policies that have environmental implications. This will include policies that are specifically directed at environmental issues, as well as those where environmental issues are more peripheral, for instance, policies related to housing have a number of environmental implications.

Practices

The aim here is to audit the practices of the local authority to establish how environmentally sound they are and to identify opportunities for improvement. It is in this area that the authority can have a direct influence on the environment and demonstrate its commitment. The opportunities to introduce measures to benefit the environment that are

identified during this stage of the audit can form part of a subsequent action programme, which can then be introduced as and when resources become available. In this regard it is considered that the audit should avoid making recommendations, merely highlight opportunities. It is the role of council committees and their officers to develop recommendations, taking into account all local sensitivities. In this way it should be possible to avoid the audit becoming a political document that requires to be agreed in detail before it is published. The politics will enter at a later stage.

There is a wide range of activities that should be included in this part of the audit, including:

Waste management

Transport

Ecology

Planning

Energy

Use of materials and chemicals

Environmental monitoring

Information and education.

In each of these areas there is a range of issues to consider. In *waste management* the audit will consider the environmental implications of the different options, identifying likely future problems, such as the existence of sufficient landfill sites and the way in which they are being run. The extent to which the authority has encouraged waste recycling also forms part of this section of the audit. In the case of *transport*, the authority can influence the introduction of traffic calming measures and pedestrianisation, it can encourage the use of public transport and cycling, and it can determine its own vehicle purchasing policy and vehicle maintenance policy, all of which have environmental implications. The *ecological issues* will include the measures being introduced to encourage wildlife, such as the establishment of wildlife parks. In terms of *planning* there is a clear overlap between practices and policies, but the issues will apply equally to the authority's own developments and will include such things as green-belt protection, inner city regeneration, environmental improvement areas and designing developments to reduce the need for the use of the private car.

An energy audit is a major project in its own right. However, as *energy* use has many environmental implications it is important to include it as a topic in the environmental audit, but mainly from the point of view of energy conservation. The audit will therefore look at whether the authority has carried out an energy audit, whether it has an energy conservation unit and whether it has set energy saving targets for its own buildings.

The audit of the use of *materials and chemicals* overlaps with the other areas to some extent. For instance the use by the authority of unleaded petrol in its vehicles relates to the transport sector. Other issues will include measures introduced by the authority to minimise the use of CFCs, its use of herbicides and its use of recycled paper.

The results of environmental monitoring are assessed as part of the state-of-the-environment review. This part of the audit is concerned with the more general issues of whether sufficient monitoring is being carried out. This will relate to whether the most appropriate information is being collected and whether there is adequate geographical spread. Account will be taken of the changing needs for monitoring. For instance, sulphur dioxide and smoke monitoring used to be of considerable importance. However, with changing patterns of pollution emissions it is now likely to be more appropriate to monitor for traffic related pollutants, such as nitrogen dioxide and carbon monoxide.

It is important to include *information and education* issues in this part of the audit, because of the important role they play in bringing about environmental improvements. Awareness is a crucial first step in the process of improving environmental quality. The audit will examine the literature produced by the authority and all other means that are used to get across the environmental message.

Conclusion

Environmental audits have an important role to play for local authorities embarking on the development of an environmental policy. They can provide the framework for the policy and highlight those issues and activities that will form the basis of an environmental action programme. The audits, though, are still new and as such are still a developing science. Each authority will probably approach the audit in a slightly different way. There is no harm in this, particularly if authorities come together from time to time to share their experience and learn from one another.

NOISE

VEHICLE SILENCING

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INTRODUCTION

As early as 1963 the Committee on the problem of Noise[1] found that the noise from vehicles would have to be reduced to about 80 dB(A) for the noise to be judged to be on the border between acceptable and noisy. A survey conducted in 1980 found that 12 per cent of the adult population of Great Britain were bothered at home by the noise of lorries using the road outside[2]. The same survey showed that vehicle noise heard indoors was as least as important a cause of nuisance as noise heard out of doors.

In 1980 the Armitage Inquiry into lorries, people and the environment[3] found that, after safety and general intrusion, noise was the most important aspect of nuisance from lorries. It was suggested that lorry noise had increased by 6 to 8 dB(A) over 20 years and that the noisiest lorries then in service (built before 1970) had noise levels of up to 96 dB(A).

THE TRRL QUIET HEAVY VEHICLE (QHV)

In 1971 the TRRL launched its quiet heavy vehicle (QHV) project[4]. The principal objective of the project was to produce two demonstration 80 dB(A) articulated vehicle tractors. The implied noise limits for the major components (all at 7.5m) were engine (including gearbox) 77 dB(A), cooling system 69 dB(A), air intake 69 dB(A), exhaust 69 dB(A). An additional low frequency limit of 90 dB(C) was also set for the exhaust. Research prototypes of these two vehicles were built by Leyland Vehicles and Foden/Rolls Royce respectively, and achieved drive-by noise levels of 79.5 dB(A) and 83.5 dB(A). A demonstration tractor was then built by Foden/Rolls Royce[5]. This was powered by an RR Eagle 320 Engine rated at 238 kW and was built to production standards. It achieved a drive-by noise level of 81.7 dB(A). Subjectively the QHV sounds smooth and non-aggressive.

The noise from the engine was reduced by turbocharging and reducing the rated speed from 2100 rev/min to 1950 rev/min, and the engine cooling system and gearbox were surrounded by a tunnel enclosure (Figure 1). A large exhaust silencer was fitted. The effect of various degrees of enclosure, and of the cooling fan, on the drive-by noise is shown in Table 1.

The drive-by noise spectra for the original and quietened vehicles are shown in Figure 2.

The demonstration vehicle was lent to a haulage contractor and between November 1979 and October 1981 it covered 118,000 km in commercial service[6]. The extra costs of servicing and maintaining the vehicle as a result of the engine enclosure were small. The vehicle proved to be completely practical and the drivers appreciated the reduced noise level.

It showed that the technology existed to build a maximum weight goods vehicle to produce less than 82 dB(A) without excessive penalties on capital or operating costs.

QUIET HEAVY VEHICLES FOR THE 1990s (QHV90)

In December 1981 a White Paper "Lorries, People and the Environment"[7] stated the Government's aim "progressively to reduce the perceived noise from new heavy lorries coming on to the road to less than half the 1981 level ..... The Government will therefore set in hand a collaborative programme ..... involving vehicle and engine manufacturers ..... to lead to the development of a 'production' quiet heavy vehicle for the 1990s -the QHV90".

The European Community Directive 84/424/EEC was agreed in September 1984 and established noise levels for heavy goods vehicles that ranged from 81 dB(A) to 84 dB(A)[8]. These came into effect in October 1989 for vehicles requiring type approval and in October 1990 for vehicles that have already been type approved. The new limits require noise reductions of 3 - 5 dB(A), and mean that between 1974 and 1989 the allowable noise from maximum weight vehicles will have been reduced from 91 dB(A) to 84 dB(A).

Manufacturers were reluctant to define projects for quieter heavy goods vehicles until the revised noise regulations had been published. This was because the technical solutions would probably change as the permitted noise level varied between 80 dB(A) and 84 dB(A). In practice, the larger QHV90 vehicles seem able to satisfy the 84 dB(A) limit with simple enclosures; to reduce noise to 80 dB(A) for these vehicles would need quite different technology, involving fully encapsulated engines.

QHV90: Programme Content

The QHV90 programme consists of three parts; the development of demonstration heavy goods vehicles; the development of quiet diesel engines; and the development of basic technology for quieter goods vehicles. Since QHV90 is intended to assist the whole of the British commercial vehicle industry to meet

the impending noise limits, the project is broader in scope than the earlier QHV. Thus it includes engines, components and goods vehicles in the weight range 5.5 - 38 tonnes[9]. The programme is given in Table 2 (vehicles) and Table 3 (engines). Manufacturers were asked to propose products which were both commercially important to them, and whose quietening would teach them lessons for the rest of their product range. The contents of the QHV90 programme have been described in detail by Tyler and Porkess[10].

<u>QHV90: Engines</u>
The 1 metre noise level of the engines at the start of the project ranged from 98 to 102 dB(A), and the target noise levels varied from 93 to 98 dB(A). The completed projects have achieved their targets and one manufacturer has done even better, using available technology suitable for production engines.

<u>QHV90: 38 Tonne Vehicles</u>
The ERF and Foden 38 tonne vehicles started with baseline noise levels of around 87 dB(A). Using improved silencers and the quietened versions of the Cummins LTA10-290 engine, initial results for both vehicles indicate that 3 - 5 dB(A) reduction in vehicle drive-by noise level is likely using only a small amount of engine shielding.

<u>QHV90: 5.5 - 16 Tonne Vehicles</u>
IVECO Ford built a test vehicle with a drive-by noise target of 79 dB(A) using several degrees of engine enclosure, naturally aspirated and turbocharged engines and noise reduced exhaust and intake systems. The results from this, together with the quietened version of the Dover engine, are enabling IVECO Ford to meet the new noise regulations.

The 11 tonne Leyland DAF prototype is based on the Roadrunner and will use a quietened version of the 300 series engine. Work on various development vehicles has included a noise source identification exercise and development and testing of the cooling, exhaust and air inlet systems.

A recent addition to the vehicle prototypes is a 5.5 tonne Renault Truck Industries 50 series light truck fitted with a quietened Perkins Phasar 4.40 engine. This will provide experience of the particular problems, if any, of reducing the noise of a relatively small goods vehicle to less than8 1 dB(A).

<u>Low Frequency Noise</u>
Low Frequency noise output as measured by dB(C) levels has proved to be dependent on silencer design. One experimental vehicle using four silencers in series showed levels of 85

dB(C) instead of 94 dB(C) with a standard silencer. This vehicle sounded smoother and quieter even though the dB(A) levels were virtually the same. The vehicle manufacturers contracted by TRRL to produce quieter vehicles have been asked to aim for about 89 dB(C) and, in the absence of legislation, it is to their credit that they are all attempting to fit the largest silencers possible.

QHV90 Technology Development

The part of the QHV90 project that is concerned with the development of basic technology is as important as those parts concerned with specific engines or vehicles.

Predicting External Noise

When designing a prototype vehicle it would be valuable to be able to calculate the drive-by noise levels from the known component noise outputs. The Motor Industry Research Association (MIRA) developed such a computer program for cars and vans some years ago. TRRL commissioned MIRA to further develop and validate their program for heavy goods vehicles. The predictive accuracy of the program has proved to be about 1 dB(A) for peak drive-by noise.

Exhaust Silencers and Air Intakes

A cooperative project within QHV90 is to develop and validate mathematical models to predict the acoustic performance and pressure drop in exhaust silencers and air intakes. Loughborough University has written a computer program to predict the sound attenuating performance of exhaust silencers. This has been validated by MIRA through idealised acoustic tests of the silencer cold and without flow, and also attached to two diesel engines[11]. The British Hydromechanical Research Association has developed methods to predict the pressure drop and internally generated flow noise in exhaust silencers[12]. The project has been most successful.

Noise from Engine Covers

Quietening the sump, rocker cover and other engine panels could reduce engine noise by around 3 dB(A). A project by Southampton University aims to provide a method based on statistical energy methods to allow engine designers to minimise noise from these sources by attention to basic shape, material and sealing methods[13].

Effectiveness of Partial Shields and Enclosures

This project, also by Southampton University, is to provide a method of calculating the attenuation and directivity of partial shields and enclosures of different shapes and percentage open area.

QUALITY OF NOISE

During the QHV90 project concern has been expressed from time to time that heavy goods vehicles that comply with reduced noise limits may not be perceived by the public as being any quieter than current vehicles. To avoid the risk that reduced objective noise levels might not be perceived as an environmental improvement, TRRL is re-examining the relation between objective measures of noise and subjective nuisance. A preliminary study has suggested that some aspects of the noise signature that are not detected in a measurement of the dB(A) sound level may be important[15]. It is as yet too early to know whether any new criterion needs to be added to the drive-by noise test.

CONCLUSIONS

During the 1970s the TRRL Quiet Heavy Vehicle programme showed that it was technically, operationally and economically feasible to build a 38 tonne heavy goods vehicle to achieve a drive-by noise level of 81 - 82 dB(A) and a low frequency noise level of 89 dB(C). In the QHV90 project (Quiet Heavy Vehicles for the 1990s), prototypes to production standards of quiet engines and quiet heavy goods vehicles of 5.5 - 38 tonnes are being developed to achieve noise limits of 81 - 84 dB(A). In addition, research projects are in progress to develop basic technology to reduce the noise from engine covers and to improve the acoustic performance of exhaust silencers, shields and partial enclosures. Results to date indicate that the noise limits of EEC Directive 84/424/EEC can be achieved without significant economic penalties, but are raising questions over whether dB(A) continues to be the most appropriate measure of vehicle noise as noise limits are reduced.

ACKNOWLEDGEMENTS

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REFERENCES

1. Wilson, A H (Chairman). Noise. Final Report. Cmnd 2056. H M Stationery Office, London. 1963.

2. Baughan, C J, Hedges, B, and Field, J. A national survey of lorry nuisance. TRRL Report SR774. Transport and Road Research Laboratory, Crowthorne. 1983.

3. Armitage, A. (Chairman). Report of the inquiry into Lorries, People and the Environment. HMSO, London. 1980.

4. Tyler, J W. TRRL quiet heavy vehicle programme. Quiet Heavy Vehicle (QHV) Project. TRRL Report SR521. Transport and Road Research Laboratory, Crowthorne. 1979.

5. Tyler, J W and Collins, J F. TRRL Quiet Heavy Vehicle Project: development of Foden/Rolls Royce demonstration vehicle. TRRL Report LR1067. Transport and Road Research Laboratory, Crowthorne. 1983.

6. Nelson, P M and Underwood, M C P. Operational performance of the TRRL quiet heavy vehicle. Transport and Road Research Laboratory, Crowthorne. 1982.

7. Department of Transport. Lorries, People and the Environment. Cmnd 8439. HMSO, London. 1981.

8. Council of the European Communities. Council Directive of 3rd September 1984 amending Directive 70/157/EEC relating to the permissible sound level and exhaust system of motor vehicles (82/424/EEC). Official Journal of the European Communities No. L238 pp 31 - 33. 1984.

9. Mitchell, C G B. Quiet Heavy Vehicles for the 1990s - The QHV90 Programme. SAE Paper 850984. Society of Automative Engineers, Warrendale. 1985.

10. Tyler, J W and Porkess, A M . The QHV90 project - progress report. Proceedings of a conference on "Advances in the Control of Vehicle Noise". Institute of Mechanical Engineers, London. 1988.

11. Callow, G D and Peat, K S. Insertion loss of engine intake and exhaust silencers. Proceedings of a conference on "Advances in the Control of Vehicle Noise". Institution of Mechanical Engineers, London. 1988.

12. Green, A J and Smith, P N. Gas flow noise and pressure loss in heavy vehicle exhaust systems. Proceedings of a conference on "Advances in the Control of Vehicle Noise". Institution of Mechanical Engineers, London. 1988.

13. Carr, I E and Lalor, N. The prediction and reduction of noise from engine covers using energy methods. Proceedings of a conference on "Advances in the Control of Vehicle Noise". Institution of Mechanical Engineers, London. 1988.

14. Sung, Y C C and Lalor, N. The prediction of engine noise reduction by using shields and partial enclosures. Proceedings of a conference on "Advances in the Control of Vehicle Noise". Institution of Mechanical Engineers, London. 1988.

15. Croker, M D. The analysis and control of engine noise quality. Proceedings of a conference on "Advances in the Control of Vehicle Noise". Institution of Mechanical Engineers, London. 1988.

TABLE 1 Noise levels for acceleration tests to BS 3425: 1966

Vehicle condition	Noise - Level dB(A) Nearside	Offside	Interpreted BS noise level dB(A)
Full enclosure without fan	81.7	79.0	81
Full enclosure with fan	82.3	79.5	82
Upper enclosure but no under tray (with fan)	84.8	84.0	84
No Enclosure (with fan)	87.3	86.0	87

Test condition: 2nd high gear

TABLE 2 Vehicles in the QHV90 Programme

Manufacturer	Designation	Config-uration	Weight Tonnes	Engines
ERF	E Series	4x2 tractor	38	Cummins LTA290 Perkins Eagle LE290
Foden Trucks	S Series	6x4 tractor	38	Cummins LTA290 Perkins Eagle LE290
Leyland DAF	Roadrunner	4x2 tractor	11	Leyland DAF 300
IVECO-Ford	Cargo	4x2 rigid	13	Ford Dover
(RTI)Renault Truck Industries	50 Series	4x2 rigid	5.5	Perkins 4.40 Phasar

TABLE 3 Engines in the QHV90 Programme

Manufacturer	Designation	Configur-ation	Capacity litres	Rating kW at rpm
Cummins	LTA10-290	6 in line turbo-charged	10	216/2100
Perkins (Gardner)	6 LXDT	6 in line turbo-charged	12	270/2100
Perkins (Rolls Royce)	Eagle LE	6 in line turbo-charged	13	260/2100
Perkins Engines	4.236 (Phasar 4.40)	4 in line NA/turbo -charged	3.9	63-79/ 2600
Ford Motor Company	Dover Range	4/6 in line NA/turbo -charged	4.1-6.2	87/2600-150/2400
Leyland DAF	300	6 in line turbo-charged	5.9	86/2500

Note: The engines section of QHV90 is managed by the DTI

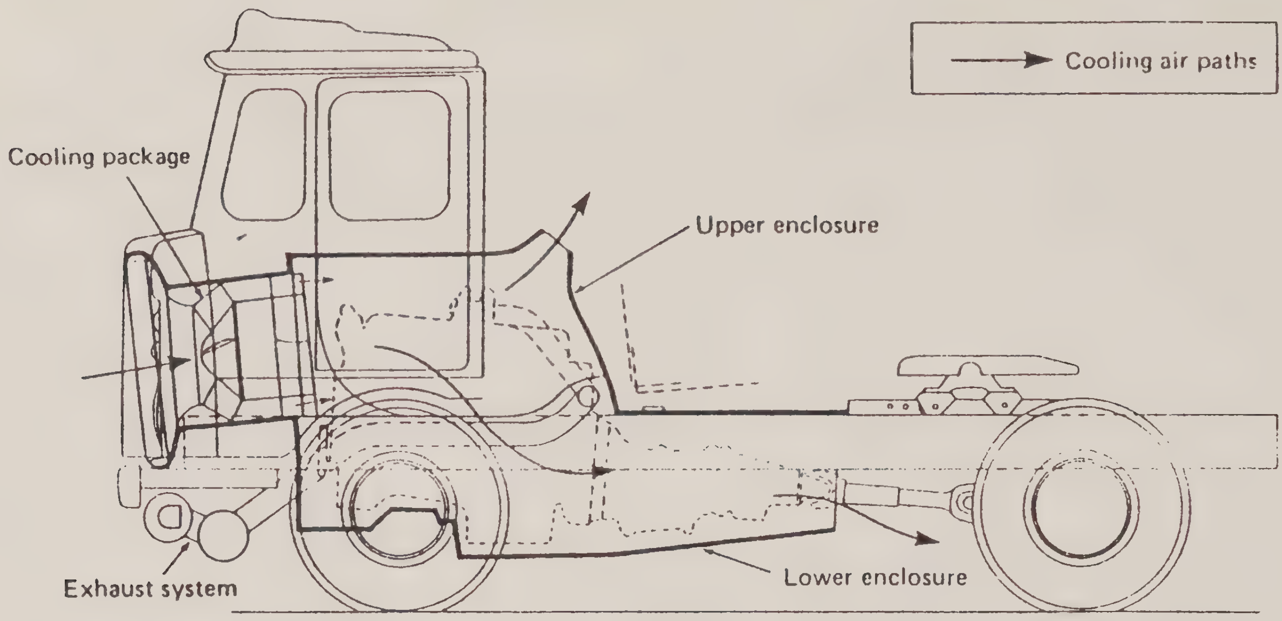

Fig. 1. Outline of QHV showing cooling system and enclosure

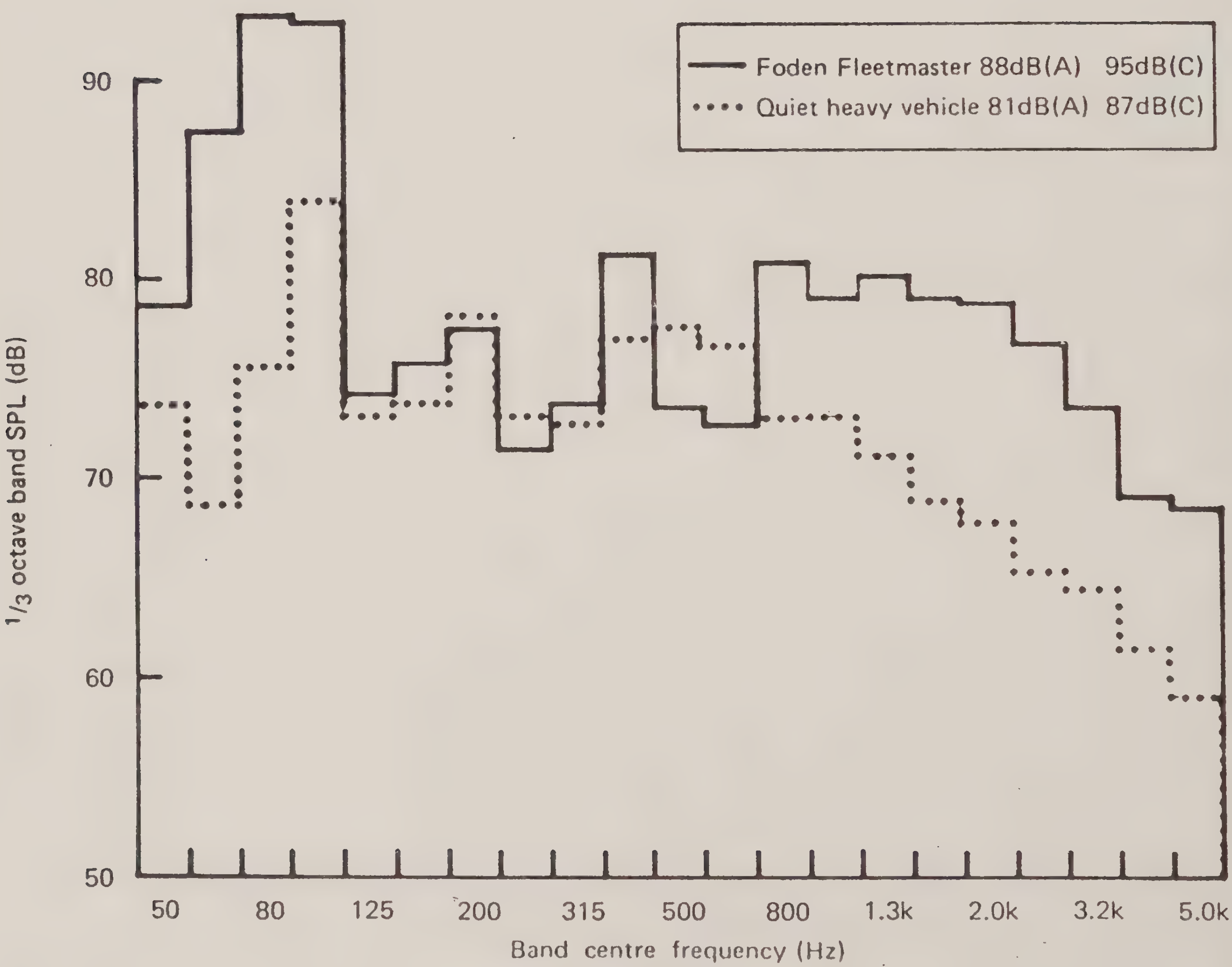

Fig. 2 Comparison of $^1/_3$ octave band spectra for QHV and Foden Fleetmaster during standard test condition 81/334/EEC (Composite peak level in each band)

NOISE

CONTROLLING NOISE FROM CLAY PIGEON SHOOTING

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Introduction

The sport of clay pigeon shooting has been around for a number of years. It is an Olympic Event and has evolved a number of different shooting disciplines to test the ability of the competitor. The Clay Pigeon Shooting Association (CPSA) estimated in their draft Code of Practice on Clay Pigeon Shooting in 1986 that by 1990 membership of their Association would be 25,000 compared with just 800 in 1965.

Unfortunately, clay pigeon shooting has a major drawback, noise. As shooting numbers have increased there has been a need to increase the number of shooting grounds to accommodate all those who want to enjoy the sport. This has in turn led to an increase in the number of complaints received with regard to noise.

As a result of the increase in complaints, and in order to assist shoot organisers and Local Authority Officers in assessing the likely impact of shooting grounds a number of Codes of Practice have been produced. These include Codes of Practice from:-

The Department of the Environment (DoE)
Surrey County Council
East Hampshire District Council
South Staffordshire District Council
Staffordshire Moorlands District Council
Midland Joint Advisory Council for Clean Air and Noise Control (MJAC)

The DoE have now published two codes in draft form which have been produced in conjunction with the sport's governing body, the CPSA. Their intention is that this Code could be approved by the Secretary of State under the powers invested in him by Section 71 of the Control of Pollution Act 1974, which would allow it to be used as a basis for a defence of 'best practicable means' if the noise were produced in the course of a trade or business. However, since the consultation exercise in Spring of 1989 the DoE have not followed up their most recent draft.

Until such time as a suitable code is found, Local Authorities

using their powers under the Control of Pollution Act 1974 must regulate the noise from clay pigeon shoots without any guidance as to the best practicable means which an approved Code of Practice would afford.

The Problem

Noise from the report of a shot-gun can be heard up to 5 kilometres from the shooter. Average distances of audibility downwind of the source, over open ground, can be in excess of 3 kilometres. It can be seen therefore that a shooting site has a major potential to inflict noise on a substantial number of people even having regard to the rural area in which the shoot is invariably situated. Noise levels at the shooter are well in excess of 100 decibels A-weighted impulsive maxima (dB(A) I Max) and this should preclude the siting of grounds immediately adjacent to dwellings. Having said that it is not always the case. Established shoots can be found by houses and there is obviously a degree of habituation for these residents.

Most complaints are received when a new shooting ground is set up. As there is no requirement in planning legislation for planning permission if the shooting ground is used on less than 28 days in any year the Local Authority has no way of preventing the setting up of a new site and has therefore to try and apply control while the activity continues. The Town and Country Planning General Development Order 1988 originally brought clay pigeon shooting in line with other significant noise-producing activities, eg motor sport, by reducing the number of days shooting could take place without the need for planning permision to 14 days. This was subsequently reverted back to the 28 days after the Department of the Environment consulted interested bodies on their views. It appeared to many people who were involved in the control of this activity at the time that the Department was swayed by the overwhelming individual responses of clay pigeon shooters who were against the reduction in days. It is therefore left to Councils' Environmental Health Departments to ensure that a nuisance is not caused.

Evaluating the Problem

In assessing the extent of the problem in relation to the noise produced from a shooting ground an Officer will take account of a number of different criteria:-

1. the day of the week
2. the time of day
3. the duration of the event
4. frequency of events

5. the number of competitors
6. the noise level at affected premises
7. the background noise level.

It may appear at first glance that the day of the week would have little to do with the likelihood of nuisance from a clay pigeon shoot. My experience however is that there is appreciable sensitivity to shooting on a Sunday. The Midland Joint Advisory Council for Clean Air and Noise Control (MJAC) in their recent code on control of noise from the sport highlighted the benefit of restricting shoots on a Sunday on the basis of the subjective reaction of complainants.

Shoots held in the evening will tend to produce a greater frequency of complaints if for no other reason than the fact that people have invariably finished work and are at home.

The length of time that a shoot carries on for will tend to have some bearing on the likelihood of complaint. Many people will accept the existence of a shoot if it goes on for a short period, say three hours in a day. In general shoots that continue throughout the day are more likely to cause complaints to be made.
Events that take place every day soon outstay their welcome. Most small shoots run without the benefit of planning permission by shooting only fortnightly, thus staying below the 28 day rule. In the assessment of noise nuisance the trade-off between noise level and the frequency of events has been established by British Standard 4142 and in the particular case of clay pigeon shooting the principle stands up well:

Many codes produced for the control of noise from clay pigeon shooting have limited the number of people shooting at any one time by specifying a number of shooting stands. This limits the possibility of simultaneous discharge which can lead to an increase in the noise level produced by both guns. Subjectively, the complainant would describe an event with large numbers of competitors as 'like World War 3 breaking out' with an almost continual crescendo of noise being produced for long periods.

Investigators always like to fall back on an objective basis for confirming their decision as to whether or not a nuisance is occurring. Noise measurement using a suitable sound level meter can help the officer to assess the problem. However, opinion is split on the dynamic response characteristic of the meter and the use of maximum or peak levels. The MJAC Code recommends maximum impulse levels averaged arithmetically over 25 or more gun reports. This may be suitable but should not be taken as the only correct way to measure the noise. The

Building Research Establishment whose representatives sat on the DoE Working Party advocate the use of the 'fast' dynamic characteristic.

The noise level measured is compared to the background level $L_{90}(A)$. It is normally accepted that it is the intrusive characterstic of the gunshots over and above the background noise level which is the important criterion when assessing the nuisance. Some acoustic consultants when arguing for the existence of a shooting site at a planning appeal have stated that it is the absolute level which is important when assessing the nuisance and not the extent of intrusion relative to background noise levels, and this theory would seem to have been adopted in the draft DoE Code. However, in unusual circumstances the level set in the DoE Code may be exceeded and shooting should be restricted where the intrusive method would allow shooting to continue, eg where shooting takes place adjacent to a motorway. As yet, no noise rating has been produced which does not have some shortcomings. I think that the only practical way of establishing an acceptable noise rating would be after a social survey has taken place.

The Legal Controls

The Control of Pollution Act 1974 is the only legislation available to Councils when trying to control the noise from clay pigeon shoots which operate on less than 28 days per year. Although I would always advocate negotiation with a shoot organiser to try and reduce to an acceptable level the noise from the gunshots, evidence for the service of a Section 58 Notice should continue to be recorded as and when it arises.

There will come a time in an investigation when, in the opinion of the Investigating Officer, no further reduction in noise levels or frequency and times of shooting can be achieved through negotiation and it must be at this stage that enough observations have been recorded to satisfy taking formal action.

The Midland Joint Advisory Council Code of Practice

The MJAC is a group which has over thirty Local Authorities within its membership based around the West Midland region. Its purpose is to provide a broad base for discussion and advice between members on various topics relating to atmospheric pollution and noise.

In January 1989 a working group was set up to produce and publish a Code of Practice on Noise from Clay Target Shooting. The MJAC were aware of an impending redraft of the DoE's Code and were concerned that it may be approved under the Control of Pollution Act 1974. The original Code, published in 1986, failed to address in any detail any effective measures for controlling the activity. Approving a Code would provide a best practicable means defence in law and the Council felt that an alternative Code needed to be produced which gave detailed advice on practical noise control.

The final MJAC Code, published last summer, has received critical acclaim and was put forward by the National Society for Clean Air and Environmental Protection, in its reply to the consultation from the DoE in 1989 as an alternative, mentioning its 'more direct style' and commending its 'eminently practical advice' on barriers. The MJAC Code was produced by a working party made up of seven Officers who had direct experience of controlling noise from clay shoots (it should be noted that the DoE's Code was made up by a group consisting of one Officer with similar experience and representatives of the Building Research Establishment, the DoE and the CPSA.

Application of the Code

The MJAC Code is designed to give advice to guide Local Authorities, shoot organisers and other interested bodies on control measures to mitigate the effect of noise from shooting. It can be applied where a new shoot is proposed or where an existing site is contemplating modifications to their layout or mode of working. Alternatively, when complaints are registered with regard to an existing site, it can be used to guide Officers and shoot organisers in the ways in which the manner of use may be adapted to mitigate any noise disturbance.

Practical Noise Control

The only effective way of controlling noise from clay pigeon shooting is at source. These methods must be considered in tandem with other factors including operational requirements, technical considerations and safety constraints, but can be summarised as follows:-

1. separation distances between source and receiver
2. shoot orientation
3. the use of natural features for screening purposes
4. control of operating times
5. construction of purpose built noise barriers

6. other considerations.

It would obviously please all concerned if noise from shooting sites was inaudible at noise sensitive premises. Unfortunately such shooting sites are rare in the British countryside and we must therefore look for reasonably acceptable solutions to the problem of noise in order to prevent nuisance being caused.

As far as separation distances are concerned no universal figure can be applied. Excessive noise levels may be experienced in excess of 2 kilometres from a site when propagation is over flat open ground. The MJAC Code states that shooting should not take place at distances of less than 1 kilometre except under well established or modified conditions which are mentioned later.

As the propagation of sound from a shot-gun has a distinct directional characteristic some benefit can be gained by orientating the shooting direction away from noise sensitive premises. However, certain shooting disciplines require the guns to be pointed in different directions and as a result each site should be looked at with this in mind. It must also be remembered that a fallout zone of 277 metres is required down line from the shooting position for safety reasons.

Further benefit can also be gained from ensuring that the muzzle/ground relationship is either parallel or pointing towards the ground. This reduces the amount of sound propagation to atmosphere taking into account absorptive ground effects.

Certain topographical features including hills and embankments can be used as an effective physical barrier to noise and when found, shooting sites should be designed to take account of the noise reduction they afford. A word of warning should, however, be given at this time. Sound reflection from features including rock faces, buildings, large expanses of water and belts of trees (if sufficiently dense) can cause substantial reverberation, exacerbating noise levels received. Gun alignment parallel to such features produce a characteristic ricochet as the sound wave impinges on the reflective surfaces as it travels down its length, which in turn increases the noise level at premises down line of the gun.

The season of year can also throw up problems. A shoot which was using the benefit of shooting from the cover of a belt of trees found that when leaves started to grow on the bare branches, the canopy produced an effect similar to a megaphone, driving the sound of the report of the gun from the

stand's position in a narrow beam.

A shooting site may not operate for more than 28 days in any calendar year without the benefit of planning permission. Having said this, it may be possible to abate a nuisance from a particular site by reducing the frequency still further to monthly rather than fortnightly.

Restrictions on Sunday shooting have already been mentioned in the section on Evaluating The Problem. I have had personal experience where stopping shooting on a Sunday has appeased complainants so that they no longer felt that a nuisance was being caused.

The MJAC Code further recommends that shooting should only be held between 1000 hours and 1800 hours inclusive, with a maxiumum consecutive shooting period of 4 hours. Both these measures seek to limit the extent of shooting and further protect people's enjoyment of their land at periods when they are likely to be at home.

Purpose-built barriers either for individual stands or for peripheral siting can prove very effective in reducing noise levels. The effectiveness of such barriers depends on a number of factors, and as each situation will prove different the following advice given in the MJAC Code is both basic and general in nature:-

a. Locate barriers as close to the noise source as is possible (the noise source should be taken as the muzzle of the shot-gun).

b. Materials used for barrier construction should be acoustically soft (eg soil, sand, straw baling, proprietary sound insulation material) on surfaces facing the gun.

c. The effective height of barriers may be enhanced if the shooting position is located in trenches or dug-outs whereby gun muzzles project only slightly above ground level.

d. As a working approximation, the length of a barrier should be at least five times its height.

e. Individual barriers should preferably be arranged around both sides of a given shooting stand to form an enclosure.

f. Where individual barriers or enclosures are utilised on

a shooting site, substantial peripheral embankments may provide further useful sound attenuation.

In simple tests, acoustic enclosures made from straw bales placed on either side of the shooting stand were able to attenuate noise levels by 7-12 dB(A) I max at 300 metres measured to the side of the stand, and 3-6 dB(A) I max down line to the same distance. Obviously, these results may not be produced in different conditions.

One all-important consideration must be addressed above all others when deciding on the noise control measures to be employed. Atmospheric considerations, especially wind speed and direction can nullify to varying degrees the measures taken to protect noise sensitive premises from the effects of shooting.

Although some attention will still be achieved by using orientation and barrier techniques, whether or not the gun report is excessive at a remote point or even audible depends on the wind direction and speed on that particular occasion. To give an example, an average noise level of 75 dB(A) I max may be typical of the sound of a gun report 500 metres from source with no discernible wind blowing. With a wind in excess of 25 miles per hour blowing from receiver to source the same gun reports would be barely audible. It is therefore very difficult to categorically state that certain control measures will prove effective in all conditions.

The most appropriate advice to persons involved in setting up sites is to carry out observations in various wind conditions to assess levels at all noise sensitive locations.

Noise Rating

The MJAC Code recommended desirable maximum exceedance levels of noise from clay pigeon shoots. While accepting the shortcomings of applying such a level, the working party felt that some guidance was required. The following levels are for a minimum of 25 gunshot reports, mean averaged and then compared to the background level, L_{90} dB(A) (using fast dynamic characteristic of at least 15 minute duration).

Background noise level range L_{90} dB(A)	Mean impulse maxima dB(A) I
40 - 45	65
35 - 40	60

The measurements are to be taken at noise sensitive premises and for the purpose of this guidance these shall include an occupied dwelling, hospital or similar institution, school, college, etc, place of worship, or premises or land used for any other purpose likely to be affected by an increase in noise levels. Where background levels fall outside the range of this guidance local consultation is recommended.

The Government Position

The present Noise Review Working Party is looking at the subject of noise in the environment and the ways in which controls are applied in complaint sitations. Discussion has taken place on the use of Codes of Practice to establish 'standards of compliance' under nuisance provisions rather than the present use for guidance on the application of 'best practicable means'. This change of emphasis may lead to the use of Codes of Practice to justify the setting up of a shooting site, where all aspects of a future Code of Practice have been complied with, which causes nuisance to nearby residents and the Local Authority are unable to abate the problem through legal channels.

The DoE are likely to confirm the use of existing Codes of Practice when the report of the Working Party is published. It is also likely that they will set out other areas where Codes of Practice will be produced and these may include:-

a. Audible Bird Scarers
b. Adventure War Games
c. Pop Concerts
d. Power Boats/Water Skiing
e. Motor Cross

as well as the proposed Code on Clay Pigeon Shooting. Many of these activities now occur on land owned by farmers and previously used for crops or grazing, but which have now been taken out of use because of the Government's incentives to diversify the use of agricultural land. To this end a further Code of Practice is possible on the recreational use of agricultural land.

A Unified Approach

There is no doubt that there is a need for a national Code to control noise from clay pigeon shooting in the same way that other similar noisy activities now have the benefit of recognised guidance.

Unfortunately, although the CPSA and the DoE must be commended on their attempt to produce such a Code, the serious

misgivings which were expressed during the consultation periods have resulted in little progress from that quarter since.

As a result of the publication of the MJAC Code in 1989, and the favourable reception it got from various bodies, the Institution of Environmental Health Officers (IEHO) are presently considering its adoption as a Code for use by Environmental Health Officers in their enforcement role. This move should be seen as an opportunity to establish a national Code for use by enforcement Officers where, at present, no such guidance is available. It presents the opportunity for a uniform standard to be applied to all shooting activities and would provide useful advice for shoot organisers and other interested persons.

I am sure that had the CPSA produced a Code which addressed the problem of noise from clay pigeon shooting and practical control measures, other bodies would not have felt the need to produce their own 'rival' Codes. Certainly the MJAC Code was produced as an alternative to their Code because of the concern of the enforcing bodies represented by the Council. They felt that any Code produced by the sport's governing body would fail to address the problem properly, because of its own conflict of interests. This self-regulation failed to take into account the expertise of Local Authority Officers who deal with the nuisance aspect of shooting at first hand, and it is my understanding that the views of the IEHO representative on the working party that produced the 1989 Code were only given minor value.

It is time that those Officers who are trying to control activities from shooting sites received advice which was applied at a national level. There is a need for a unified approach.

Please note that the views expressed in this paper are the the author's and may not be those of his employing Authority.

NOISE

ASSESSMENT AND CONTROL OF NOISE FROM NEW DEVELOPMENTS

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1. INTRODUCTION

In the UK, new development is controlled under the provisions of the Town and Country Planning Act 1971. The definition of "development" is open to a wide interpretation and includes, for example, a change of use as well as the erection of new buildings. All aspects of the environmental impact of development, including noise, can be regulated by the planning process. Under the terms of DOE circular 10/73 "planning and noise", planning authorities are obliged to consult with environmental health departments on applications for planning permission which may have implications of additional noise.

The scrutiny of planning applications and assessment of their environmental impact is one of the most valuable pro-active areas of work for Environmental Health Officers. The old adage "prevention is better than cure" should be firmly fixed in our minds. In an ideal world, if every planning application was properly dealt with then there would be no new justified sources of noise and pollution complaints.

The economic pressures to grant permission for industrial and commercial development are often very strong. We must ensure that the environmental effects are also taken into account so that Planning Committees can strike the right balance. Hopefully it will rarely be a straight choice between either employment or the environment. It is the job of Environmental Health Officers to recommend solutions for potential noise and pollution problems, thus ensuring that development can proceed without conflicting with the needs of local residents. However, there will inevitably be some applications which are incompatible. It is then our clear duty to recommend refusal and to substantiate this, on appeal if necessary.

2. REPLIES TO PLANNING CONSULTATIONS

Replies will normally fall into one of four categories:

(a) no comment
(b) any permission granted should be subject to the following condition(s) ...
(c) refusal is recommended because ...
(d) refusal is recommended because ... However, if the

granting of permission is being considered then conditions can be suggested on request which would mitigate in part the environmental impact of the development.

In the case of replies in category (b) the actual condition(s) should be recommended, by reference to model conditions, if possible.

Officers should remember that planning consultation replies are public documents. Applicants have a right of access to them and could use the information in an appeal. Vague and generalised comments should be avoided, as should anything that might cause embarrassment.

3. THE USE OF CONDITIONS IN PLANNING PERMISSIONS

In order to properly assess a planning consultation it is necessary to have an understanding of what conditions could be imposed by the Planning Authority. Detailed advice on this subject is contained in DOE circulars 10/73 and 1/85. Six tests are laid down which all planning conditions must satisfy. Each condition must be: (a) necessary, (b) relevant to planning, (c) relevant to the development under consideration, (d) enforceable, (e) precise, (f) reasonable.

Conditions recommended under paragraph 2.1(b) should satisfy these tests.

It should be remembered that whilst the power of a planning authority to impose conditions is very wide, it is not unlimited. If conditions which satisfy all six tests cannot be framed so as to make the development acceptable, then the proper course of action is to recommend refusal.

However, sometimes matters outside the scope of planning conditions can be influenced by means of an agreement under section 52 of the Town and Country Planning Act. Section 52 agreements would not normally cover potential noise or pollution problems. As the name suggests, they are voluntary and require the agreement of the applicant. They often relate to matters outside the boundary of the site and not strictly relevant to the planning application in question.

The six tests for conditions are considered in more detail:

(a) <u>Need for a Condition</u>

The basic question is, would planning permission have to be refused if the particular conditions was not imposed?"

Conditions which duplicate existing legislation are unnecessary, e.g. "no nuisance shall be caused by the development". This is a bad planning condition, often used in the past. It is unnecessary because the general law of nuisance applies anyway. Such a condition is also imprecise and fails the test outlined in (e) below.

Permissions should not be overloaded with unnecessary conditions. For example it would be more appropriate when dealing with noise control to agree a scheme of works with the applicant beforehand and impose a condition that all work must be carried out and thereafter retained in complete accordance with the approved plans and specifications, rather than recite a long list of technical conditions one by one.

In deciding whether or not a noise control condition is necessary, it is advisable to look at the use, or proposed use, of adjacent land. For example, land which is zoned for housing on an approved Local Plan should be assumed to have houses on it.

(b) <u>Relevance to Planning</u>

A condition which has no relevance to planning is ultra vires. For example, a condition relating to internal noise levels to protect workers would not be relevant to planning.

(c) <u>Relevance to the Development to be Permitted</u>

Unless a condition fairly and reasonably relates to the development to be permitted it will be ultra vires. It is not sufficient for a condition to be generally related to planning or environmental health objectives. For example, if planning permission is being granted for the extension of a factory building, it would be wrong to impose conditions relating to noise from existing processes in the established building. However, a condition could be proper to require additional noise control measures in the existing factory building, if a problem would arise out of the effects of the proposed extension, because of over intensification due to additional plant or machinery and longer working hours. In essence, if the situation before the proposed extension was satisfactory, but the development will result in a noise problem arising, then the condition is relevant.

(d) Ability to Enforce

A condition should not be imposed if it cannot be enforced. The feasibility of monitoring for compliance must be considered.

An example of an unenforceable condition would be one which required a certain noise level to be complied with at the boundary of the site, where it would be impossible to obtain access at that point, for example, if the boundary was a party wall with neighbouring property. However, mere inconvenience to the officers concerned cannot be taken into account. For example, a requirement for the use of premises to cease at midnight is perfectly enforceable, despite the unsocial hours involved for the officer who has to visit.

(e) Precision

A condition which is not sufficiently precise for the applicant to know what must be done to comply with it is ultra vires and cannot be imposed. Vague expressions which have appeared in conditions in the past such as "so as not to cause annoyance to nearby residents" or "the best practicable means should be employed to minimise noise" give developers little idea of what is expected of them. Conditions should provide objective and specific criteria so that the applicant knows what must be done. A precise noise level condition is acceptable and often necessary, e.g. "an equivalent continuous sound pressure level of ... dBA should not be exceeded as measured over any ... hour period, as measured at ...".

The framing of conditions requires care to ensure that the condition is not only precise but achieves the desired aim. A condition requiring for example that "a sound insulation scheme shall be submitted for the approval of the Local Planning Authority" is incomplete and meaningless, since if the applicant were to submit the scheme and obtain approval for it but neglected to carry it out it is unlikely that the Planning Authority would be able to take further action. In such a case, the requirement which should be imposed is for sound insulation to be carried out in accordance with a scheme to be approved by the Local Planning Authority, and thereafter retained.

(f) Reasonableness

A condition can be ultra vires on the grounds of unreasonableness, even though it may be precisely worded and apparently within the powers available. A condition may be unreasonable because it is unduly restrictive and effectively nullifies the benefit of the permission. For example, it would be unreasonable to restrict the opening hours of a night club to close at, say, 8 pm if that was out of character with a night club and would render the proper running of the business impossible.

If it appears that development would only be acceptable subject to conditions that would be likely to be held unreasonable by the Courts, then permission should be refused. An unduly onerous condition can never be made acceptable by offering the prospect of informal relaxation.

An unreasonable condition cannot be imposed because an applicant suggests it or consents to its terms. Unless there are exceptional circumstances which justify a personal permission (see later guidance) the condition will run with the land. If the applicant moves on, the unreasonable condition would still be binding on a successor. Conditions must always be justified on their planning merits.

4. DEVELOPMENT CONTROL

Outline Permissions

Any applicant who proposed to carry out building operations may choose either to apply for full planning permission or for outline permission. If a consultation is received for an outline planning application it is important to remember that conditions to control noise levels must be imposed at the outline stage. Only certain specific matters can be reserved for conditions on the subsequent final approval. These are the siting of the building, its design, its external appearance, the means of access and the landscaping of the site. It could be argued that some of these, e.g. the siting of the building and its design, could influence the environmental impact of the development on nearby residents. If so, then the consultation reply should clearly state the recommendation for a reserved condition and the reason. Otherwise, all consultation replies for outline applications should give a specific recommendation as if dealing with the final application.

Renewal of Permission

Where a time limit on a temporary planning permission has expired, an application may be made for its renewal. However, if a noise problem has arisen, but appropriate conditions were not put on the original permission, it may not be possible to correct the situation. As a general rule, applications for renewal can only be refused or new conditions imposed where

(a) there has been some material change in planning circumstances since the original permission was granted, or

(b) continued failure to begin the development will contribute unacceptably to uncertainty about the future pattern of development in the area, or

(c) the application is premature because the permission still has a reasonable time to run.

Consultation replies should therefore be framed with these principles in mind.

Restrictions on Use

Development Orders and the Use Classes Order are designed to give freedom from detailed planning control which will be acceptable in the great majority of cases. However, it is possible to impose conditions to restrict further development or changes of use which would not normally be regarded as development (because the change is either not "material" within the terms of Section 22 of the Town and Country Planning Act or it is within the provisions of the Use Classes Order). Changes of use can be restricted either by prohibiting any change from the use described in the application and subsequently permitted or by precluding specific alternative uses. An example where this might be necessary to control noise is the use of a building for storage only and not manufacturing.

It should be noted however that a condition restricting changes of use will not normally restrict "ancillary or incidental activities" unless it so specifies. Such a recommendation should only be made where there are clear reasons to preclude or regulate activities which might give rise to noise, e.g. the repair of motor vehicles as ancillary to their sale.

Personal Permissions

Planning controls are concerned with the use of land rather than the identity of the user and the question of who is to occupy the premises for which planning permission is to be granted will normally be irrelevant. However, there might be exceptional occasions when a permission could be considered for the use of a building or land for some purpose which would normally be refused, if there are strong grounds personal to the applicant which might make the proposal acceptable. For example, where a person has been made redundant and is trying to establish a relatively innocuous type of business which the Council as a whole might want to encourage. In such a case, a permission could be granted subject to a condition that it is only for the benefit of the applicant by name. Many such small businesses can give rise to complaints and other conditions should always be imposed to control noise, e.g. working hours, boundary site levels etc.

Temporary Permissions

Planning Authorities have powers to impose a condition requiring that a use be discontinued at the end of a specified period. Such a condition is appropriate when a trial run is needed in order to assess the effect of the development on the area. However, the reason for granting a temporary permission should not be that a detrimental effect on the amenities of the area is considered acceptable for a certain period of time. Instead such detrimental effects should be prevented by conditions whose requirements would safeguard the amenities in the area. If it is not possible to devise such conditions and the effects are unacceptable, then the only course open is to recommend refusal. Temporary permissions are a useful way of assessing the noise impact of a development where traditional methods of prediction, e.g. BS 4142 are inappropriate.

A trial period should be set sufficiently long enough to assess whether permanent permission or a refusal is the proper course of action. There is a general presumption against second temporary permissions.

5. NOISE ASSESSMENT

Circular 10/73 "Planning and Noise" has been the substantive reference document now for over 17 years. It is long overdue for revision. As far as industrial

noise is concerned, it relies heavily on BS 4142, a revised version of which has also been promised for some time. Problems met in practice with both these documents will be dealt with in my verbal presentation to conference. In the meantime, it must be recognised that both circular 10/73 and BS 4142 still stand and regard must be had to them, despite their disadvantages.

6. CONCLUSION

In general terms, there is adequate provision within the planning system for the control of noise from new development. In practice, problems arise because of inadequate communications and misunderstanding between Planners and Environmental Health Officers. The enforcement of planning law is a complex and time consuming business. Frustrating delays can occur if a developer decides to contest enforcement action. In these circumstances, there is often pressure from complainants for the local authority to deal with noise problems under nuisance legislation. This can also be a difficult business and it should be remembered at the end of the day that nuisance is a poor standard, dealing with material interference with a person's use and enjoyment of their property, whereas planning should be a higher standard, concerned with the preservation of amenity.

Appendix A

SUGGESTED MODEL CONDITIONS FOR USE IN APPROPRIATE CIRCUMSTANCES TO CONTROL NOISE (From DOE Circular 1/85)

1. No condition should be imposed unless, having regard to the circumstances of each case, it meets the tests set out in the Annex to this Circular. The conditions set out below are only models, and may need adaptation to the circumstances of particular cases.

2. This list is not exhaustive, and it will be possible to word many acceptable conditions to meet planning problems which are not mentioned here.

... (activities) shall not take place anywhere on the site except within ... building(s).

The conditions should describe precisely the activities to be controlled as well as the particular building(s) in which they are to take place.

The building shall be so (constructed/adapted) as to provide sound attenuation against internally generated noise of not less than ...dB averaged over the frequency range 100 to 3150 Hz.

Noise emitted from the site shall not exceed (a) dB as a (b) minute/hour LAeq between (c) and (c) hours Monday to Friday and (a) dB expressed as a (b) minute/hour LAeq at any other time, measured on the (d) boundary (boundaries) of the site/at point(s) (e).

Specify *a - noise level*
b - period
c - times
d - boundary (boundaries)
e - points

(No *(specified machinery)* shall be operated on the premises) before ... am on weekdays and ... am on Saturdays nor after ... pm on weekdays and ... pm on Saturdays (nor at any time on Sundays or bank holidays).

Before (any) *(specified)* plant and machinery is used on the premises, it shall be enclosed with sound-insulating material in accordance with a scheme to be agreed with the local planning authority.

This condition might be varied where the need was to

secure the satisfactory mounting of the machinery to prevent conducted noise and vibration. Advice should be appended to the permission, indicating the attenuation aimed at.

Development shall not begin until a scheme for protecting the proposed dwellings from noise from the ... road has been submitted to and approved by the local planning authority, and all works which form part of the scheme shall be completed before any of the permitted dwellings is occupied.

Authorities should give applicants guidance on the extent of noise attenuation to be aimed at within or around the dwellings, so as to provide precise guidelines for the scheme to be submitted.

TOXICS AND NUISANCE

PESTICIDE SPRAYING AND HUMAN HEALTH

P. Beaumont

The Pesticides Trust

"Pesticide" is a general term used to describe any chemical that kills or controls pests, or affects plant or animal life. "Pests" can be weeds, greenfly, fungal diseases in crops, or woodworm. Pesticides can be used in homes and gardens, parks and factories, and in public health applications, as well as on farms and orchards.

Why are pesticides found in the body fat of Antarctic penguins? How do 90% of organochlorine pesticides used in the Caribbean seemingly end up in the atmosphere? Why does it rain pesticides? Pesticides are important in food production and in public health. This paper looks at how pesticide spraying leads to their presence in air, and the implications for human health.

The sources of pesticides in air

Pesticides are toxic chemicals intended to kill or harm life. They are used in great quantities: in 1987, 26.5 million kg of active ingredients were used in Britain (BAA 1988), or the equivalent of a quarter of a pound of active ingredient per head of population. Pesticides are used over large areas of land; the estimated treated area in 1983 was nearly 26 million acres, and many crops receive multiple applications of pesticides. Finally, people have no control over their exposure: workers risk occupational exposure, but the general public is exposed through spray drift from fields and parks and home use, and from residues of pesticides in food and water.

The main use of pesticides is in agriculture, and the most common methods of application involve spraying. The principal source of airborne pesticides is spray application by tractor-drawn booms, knapsack sprayers and crop-spraying aircraft.

What happens to the spray from any of the estimated 100,000 or so pieces of spray machinery that are reckoned to be in use? There are three main types of "spray drift", which correspond to the liquid, solid, and vapour phases of the pesticide formulation:

i) Droplet drift, which is the drift of small liquid spray droplets.

ii) Vapour drift, which refers to the volatilisation of some pesticides after they have impacted onto the plant, and the subsequent drifting of vapour. The evaporation of droplets also leads to vapour.

iii) Blow, which is the blowing of granular pesticides, or the adherence of solid particulate to dust and other impurities in the atmosphere.

How are pesticides transported in air?

Droplet drift is the first serious problem. This is caused by air currents carrying spray droplets away from the target area. This can result in damage to neighbouring non-target crops. It can also result in other parties being involuntarily exposed to pesticides. Those exposed may be neighbours, or they may be passers-by, walkers, or other amenity users. They may also be organic farmers and growers, or their crops. The occupants of neighbouring buildings or institutions may also be affected: these may include schools or hospitals.

Aerial spraying is the means of application that causes most anger to the general public. In spite of conditions of application laid down by MAFF, and the Civil Aviation Authority, and the particular chemicals that are to be used, incidents continue to occur. The public outcry has reduced aerial spraying to about 1% of all applications in Britain, but it is much more prevalent in the US where crops are farmed on a larger scale.

Pesticides reach air, however, even after application. Pesticides volatilise from the soil surface, and from the surface of the target crop. In experiments to measure the volatilisation of pesticides following an application to turf grass, research has demonstrated that under conditions of high temperature and strong winds, as much as 50% of the applied herbicide was lost by volatilisation within 30 days of application. Under normal weather conditions, as much as 40% was lost, with half of this amount being lost in the first 3 days after application (Mueth 1990). Other experimenters looking at the loss from wheat and cotton have noted losses from 12-99% to air (Boehncke 1990).

More surprising results have been noted. The application of the herbicide trifluralin is lost by migration into the air from soil - even when it is incorporated beneath the surface. If incorporated at a depth of 2.5 cm researchers noted a 22%

loss to air after 120 days. If incorporated at 7.5 cm there still occurred a 3.4% loss after 90 days. Methyl bromide, a soil fumigant, is directly injected into trenches in the soil which are then filled, and covered with a polythene tarpaulin. High concentrations of pesticide have been reported over the plastic surface, the fumigant escaping through the covering.

The phenomenon of pesticides passing into the atmosphere is not a feature only of the agricultural, outdoor use of pesticides. Pesticides are used, as wood preservatives, in the home. It is estimated that 100,000 buildings receive such remedial treatment every year in the UK. It has been suggested that after the first month following heavy treatment for wood decay, concentrations of PCP of up to 30 microgm/cubic metre can be expected (Dobbs & Williams 1983). This approaches the occupational exposure limit that regulates worker exposure: except that those exposed at home may be the young or the elderly or infirm.

How do pesticides reach the Antarctic?

It has been found extremely difficult to model the migration of solid, liquid, or vapour phases of pesticide chemicals, and particularly so between soil and air and in air. The factors of lack of the homogeneity of the medium, and turbulence, have yet to lend themselves to measurement and prediction. Some features, however, do emerge.

The persistence of a pesticide affects the distance it can be transported in air. Rapid degradation means that air transport and distribution is unlikely to happen on a large scale. The relatively short half-life of some organophosphorous compounds, for example, means that they do not last long enough to persist in air. However, particularly stable pesticides may have a longer "residence" time in air. If they have a half-life approaching, say, a month, this is reckoned to contribute to residence in the local atmosphere, and possibly long-distance transport by global wind and weather systems.

In the atmosphere of Natal, South Africa, hormone herbicides have been found from 1987-9 in 5% of air samples, 11% of dew samples, and 15% of rain samples (Van Dyk 1990). The research was instituted in response to allegations that crops had been damaged by vapour drift of these herbicides. The conclusion was drawn that traces of herbicide as found could have led to damage to susceptible crops like tomatoes. Again, transport of the herbicide 2,4-D over 10-50 miles was found, in the Washington area of the US, following crop damage occurring many miles away from usage.

What happens to pesticides in air?

Until recently, it had rather been assumed that the loss of pesticides to air had negligible effects, because the atmosphere was able infinitely to dilute concentrations. The realisation has now come that chemicals in air can be re-deposited or transformed, and that both processes can have damaging consequences to health.

DDT has been found in the soils of Oregon coastal mountain areas, 64 km. from the edge of agricultural regions. DDT concentrations in the atmosphere of the Arabian Sea and Indian Ocean, offshore from nations where DDT is still used, are 25-40 times the level in the atmosphere offshore from the North Atlantic, where DDT has been banned for some years. Lindane, another persistent organochlorine pesticide, is found in increasing concentrations in the North Sea (Lohse et al, 1990). It is thought to have been deposited after air transport following heavy use in Eastern European countries.

Even pesticides not regarded as persistent can have sufficiently long residence times to be carried great distances in air and to be deposited again in fog or rain. Commentators are also concerned at the ability of pesticides to form enriched solutions in fog droplets, such that the concentrations of chemicals found are orders of magnitude greater than expected from their distribution in air.

In the atmosphere, pesticides can undergo photochemical and other transformation reactions. Methyl bromide, a widely used fumigant, is now thought to be an ozone-depleter. The molecules of phenoxy herbicides are thought to be oxidised and subsequently nitrated to form acid rain. We can no longer spray pesticides and assume that protective clothing is all that is required to minimise the consequences of use.

What do we know about the health hazards of pesticides?

"The primary hazard of pesticide exposure is the development of acute toxic reactions as a result of dermal contact with, or inhalation of a relatively large dose" (AMA 1988). Acute health effects of exposure to pesticides range from eye and upper respiratory tract irritation and contact dermatitis to systemic poisoning, which can lead to death.

The greatest hazard is the acute hazard run by those who use pesticides. The California Department of Food and Agriculture is responsible for the health and safety of workers in a population comparable to that of England and Wales. The rate of ill-health among agricultural workers in general, as diagnosed and confirmed by doctors, is reckoned to be 1.4 per

10,000. The same rate among pesticides mixers, loaders and applicators, is 50 per 10,000 - or 30 times greater, and this in a literate society with good health and safety education and regulation.

The acute or short term effect is a risk to those in the vicinity of spray operations as well as the spray personnel. This includes the families of farmers, growers, and those who live in or near areas subject to spray treatments. It also includes walkers, neighbours, and those who are in hospitals, schools, or provision for the elderly in such areas. In urban areas it includes those who use amenity areas like parks and gardens after treatment, or public or private buildings after the use of pesticides for public health purposes.

HSE's Agricultural Inspectorate investigates reports of incidents made by users, generally agricultural, the public, and Agricultural Inspectors. HSE's figures are published annually in its Pesticides Incidents in Agriculture Report. In 1987, the Agricultural Inspectorate investigated 63 suspected poisoning incidents involving pesticides. Twenty-two were confirmed.

It is the common experience of members of the public as reported to The Pesticides Trust that HSE inspectors seem overworked and unable to investigate a number of reports made to them. Given the shortage of resources and the increased responsibilities the Inspectorate has been allocated under The Food and Environmental Protection Act (FEPA), this may not be surprising.

The most recent estimate of acute poisoning incidents in the UK was given by The National Poisons Unit (ENDS Report 1986). It was suggested that up to 5000 people in England and Wales suffer acute poisoning from pesticides. Most of these are thought to be deliberate poisoning cases, or accidental, rather than occupational. Dr. Murray of The National Poisons Unit considered that "a sizeable proportion of incidents are not reported to us" in giving evidence to the House of Commons Agriculture Committee (HMSO 1987) (Vol. II p. 293). Dudley quotes the research of Dr. Joyce Tait of The Open University (Dudley 1987) to the effect that of a small survey of 80 farmers, 41 felt that they had been made ill by pesticide use, but only one had reported the incident to HSE. HSE acknowledged in evidence to the House of Commons Agriculture Committee Report that under-reporting might be a problem.

The Body Report itself considered the under-reporting of incidents to constitute a serious problem. Some acute symptoms are of such a frequent, mild, and short-lived nature, as to

be difficult to ascribe to pesticides. Equally, Body continues "..while it is true that many such mild symptoms may be wrongfully assigned to pesticide use, it is at least as likely that sickness caused by pesticide exposure may be ascribed to other causes".

Official records comprise records of acute poisonings only: there is little or no accurate information about the chronic adverse effects of pesticides upon human health. There have been in recent years a number of significant compilations of case histories and relatively small-scale surveys that have drawn attention to pesticide incidents. Such reports draw attention to both acute and chronic effects. Friends of the Earth have published influential reports of pesticide poisoning incidents, in 1985 (FOE 1985) and in 1987 (FOE 1987).

A joint report prepared by the three unions TGWU, NUPE, and GMB in 1986 as a result of a survey of members produced 297 respondents. Fifty per cent said they had suffered symptoms of mild pesticide poisoning - headaches, sickness, and sore throat - after using pesticides at work. Eighty per cent of the respondents wore protective clothing.

Such is the lack of support and information that can be offered to those who consider they are victims of pesticide poisoning, a new support group has been set up. The Pesticide Exposure Group of Sufferers (PEGS) has over 4000 cases already on its files.

The report of The London Hazards Centre on timber treatment and the use of wood preservatives (London Hazards Centre 1989) draws for its information on case-files collected over the years and numbering some hundreds - information from workers in the trade, and householders who consider their health has been adversely affected by wood preservatives.

The chronic or long term effects

Can pesticides cause long-term ill-health? The onset of chronic symptoms may take some time, by which time the trail of causation is difficult, if not impossible, to follow. Cancer may well take half a lifetime to manifest itself following exposure: and the consequences of exposure to long-term low doses of carcinogens are simply not known. Pesticides, unlike pharmaceuticals, cannot be tested in humans, and so the monitoring of safe use is particularly important. Some 70% of pesticides are considered to fall within the definition of "substances hazardous to health" within the Control of Substances Hazardous to Health Regulations 1988.

Many pesticides have been in use for forty years or more, and the state of scientific knowledge is increasing rapidly. Many of the older compounds have not been reviewed in recent years to ensure that they continue to be regarded as safe in the light of current scientific knowledge. MAFF have announced a review programme of pesticides, including a review of some 250 or so of the 440 active ingredients approved for use. The majority of these were approved before 1980. The Ministry does not have the scientific or financial resources to complete the review until the next 10-20 years. The Pesticides Trust, in common with a coalition of other groups including The Green Alliance, The Transport and General Workers Union, Friends of the Earth, The National Federation of Women's Institutes, and The British Agrochemicals Association, has called upon the government to increase the resources devoted to reviewing older pesticides, and to enforcing safe use of pesticides by HSE. The coalition also sought the establishment of a National Pesticides Incidents Monitoring Scheme.

What is the state of knowledge about one of the most serious chronic effects, cancer? There are authoritative and respected classifications of the carcinogenicity of pesticides.

The recent updating of the IARC's series of evaluations (IARC 1987) lists two pesticides only of Group 1 (arsenical pesticides, and vinyl chloride). It lists one probably carcinogenic pesticide (ethylene dibromide); 17 possibly carcinogenic pesticides; 26 not classifiable pesticides. Only one substance has gained the accolade of "probably not carcinogenic".

IARC does not have the resources to review all chemicals or all pesticides. Nevertheless the pesticides reviewed by IARC are but a small fraction of those causing concern, and an even smaller fraction of the number of active ingredients in use in the UK. It is frequently unable to evaluate the most widely used, or established pesticides due to data gaps, and does not consider "newer" active ingredients for many years.

In a selection of 72 pesticides of major economic importance worldwide, IARC was able to provide cancer classifications for only three. US EPA cancer classifications are available for 18 of those pesticides (G. Ekstrom, M. Akerblom 1990).

The US National Research Council, in a study of the regulation of pesticides in food and health risks, quoted the EPA's view that on the basis of the weight of active ingredient applied to food crops, 60% of all herbicides applied were oncogenic or potentially oncogenic in animal studies, as were 90% by volume of all fungicides applied, and

30% of all insecticides (NRC 1987). Although British regulators do not take the same view of the carcinogenic hazards as their American counterparts, the differing views of the hazards of pesticides must be explained to the public.

What can be done: reductions in use

The strategy now being considered is that of fundamental cutbacks in pesticide use. In order to reduce the risks associated with overuse and misuse of pesticides, some countries have proposed reducing use by as much as 50% of current levels. Such a strategy requires that there is good knowledge of the current pattern of pesticide use; and that there is a working understanding of what constitutes a "reduction".

What is reduction in use? We are not at all sure what amounts of particular pesticides are currently in use. The amount of pesticides in use is not given by the weight or volume used, as neither weight nor volume relate directly to toxicity or efficacy. Pesticides requiring lower application rates are by definition more biologically active. A better indication is to record the area over which pesticides are applied, coupled with the number of applications. Industry claims, therefore, that the amount of pesticides in circulation are reduced needs to be treated with caution. The "lesser" amount of pesticides are often more powerful.

A number of agricultural nations are now experimenting with programmes of reduced pesticide usage that do not significantly affect yield. Denmark developed a plan in 1985 to reduce the use of pesticides by 50% before 1997. In Sweden, a programme was put forward in 1988 to reduce pesticide use by 50% in five years. A programme is being developed in the Netherlands which would reduce pesticide use by 50% in ten years. Similar plans are also being examined in the USA and the EC.

Even user groups are now conscious of the need to consider reductions. Despite the availability of new products, many farmers and landowners think that their colleagues are using too great a quantity of pesticides (Farmers Weekly 8 Dec. 1989). A recent consortium of growers organisations has announced that it is proposing to advise its members to restrict the number of sprays per season. In addition, research from the Scottish Agricultural Colleges recently announced has indicated that cutting the application of herbicides to, in some instances, as little as one-eighth of normal application rates, has not affected yields. In some cases, yields have actually increased (Farmers Weekly 6th April 1990).

The encouragement and application of organic and "low-input" techniques and alternatives to pesticides will greatly assist this trend. In the Third World, where pesticides overuse and misuse is the greatest, the policy of reduction may well have to include the banning or severely restricting the more toxic or hazardous classes of pesticides altogether, unless it can be shown that no legitimate alternatives exist.

What can be done: new technology

Of the pesticides applied by spraying, only 10%-15% may reach the target crop, with the remaining 85%-90% dispersed off-target to air, water, or soil (G. Matthews 1982). It has been estimated that of the one billion gallons of pesticide spray used each year, as much as 200 million gallons may drift off-target (Dudley 1984). If the spray is directed towards insect pests, it has been calculated that less than 1% of insecticide is actually effective in killing insect pests. Indeed, some calculations carried out after test applications indicate that percentages may be as low as 0.003% and 0.03%. Applications of contact fungicides may have even less chance of success because fungal targets are so small (Pimental et al 1986).

Clearly more efficient means of delivery of pesticides to the pests may reduce the hazard to operators and the public. Spray technology is not as advanced as the agrochemicals used. Reviewing trends in application methods, Matthews remarks "Looking back at the history of pesticide application, one can argue that changes take place slowly as we are still using chemicals diluted in water and pumped through hydraulic fan and cone nozzles in much the same way as Lodeman (The Spraying of Plants: L. Lodeman: MacMillan Press: 1896) described a century ago".

Pesticides sprayed through a conventional hydraulic nozzle are released in a wide range of droplet sizes, from very large droplets to extrememly small droplets. Large drops tend to bounce straight off a crop and be lost, while droplets of less than 100 microns in diameter are likely to drift almost indefinitely. If water is used as a dilutant, this quickly evaporates, leaving a greater concentration of chemical. In windy conditions, even more of the pesticide is blown away. Research by the Centre for Tropical Pest Control in Ascot suggests that up to 20% of spray from a hydraulic nozzle is in droplets of less than 100 microns in diameter. These are liable to add substantially to drift, and to expose people living in rural districts to chronic doses of a mixture of farm chemicals.

More efficient sprayers exist, although several of these are still under development. The National Institute of Agricultural Engineering estimate (Body op. cit. Vol II p. 263) that "a 50% reduction (of pesticides used) must be in prospect" through improvements in technical efficiency.

What can be done: information about pesticides

There is also a need to ensure that there is freedom of access to information about pesticides so that those who have suffered adverse effects, and their advisors, can have access to toxicity data about products, and so that users can make rational choices from the available products.

Prior notice of agricultural and horticultural spraying should be given to neighbours and those likely to be affected by the problems of drift. Thus, schools or hospitals whose grounds abut onto fields that are to be sprayed should be notified before spraying commences. They should also be given details of the chemicals proposed to be used, and a contact point where further information can be obtained on the nature and effects of the pesticides concerned. Warnings can be posted at field boundaries, with similar information and details of safe re-entry periods. Similar provisions have been incorporated into legislation in California. The US EPA provides a "hot line" for the giving of telephone advice about pesticide spraying and poisoning incidents.

In New York, legislation has been enacted to ensure that timber treatment firms who propose to treat such premises, or flats in buildings where there are other residential occupiers, are required to give prior notice of their intention to do the work. The notice has to be given to tenants and freeholders of the intention to spray, and has to provide health and safety information and a contact point for further enquiries.

The particular problems associated with pesticide poisoning indicate that the present reporting systems should feed into a single coordinated system to monitor pesticide poisoning. The Pesticides Trust now understands that the Advisory Committee on Pesticides has asked HSE to commission a feasibility study to evaluate the different schemes for reporting pesticide poisoning, to see if a unitary system can improve the data available. This is a welcome move.

The effects of pesticide spraying on human health

The short term acute effects are primarily those of operator exposure. A further consequence is that of the effects of spray drift upon urban or rural neighbours and residents.

In the Third World, the World Health Organisation (WHO/UNEP 1989) estimates that some 3 million people will suffer the effects of acute severe pesticides poisoning.

The long term and sub-acute effects are harder to determine. There is a need to know a great deal more about pesticides. Air transport means that the effects can travel far away from the cause. The deposition of pesticides gives cause for concern: the rate of increase of pollution and the difficulty of cleaning the environment means that we are courting risk.

Given the potential increase in use of pesticides, reduction strategies and research into the long term health and environmental effects are called for. What comes down eventually goes up. If we can use less pesticides and still produce food and safeguard our health, we should clearly try to do so.

References

American Medical Association Council on Scientific Affairs: Cancer Risk of Pesticides in Agricultural Workers: JAMA 260/7 1988

British Agrochemicals Association: Annual Report 1987-88: BAA 1988

A. Boehncke, A Curtis: Volatilisation of Selected Pesticides from Glass, Leaf, and Soil Surfaces: Proceedings of IUPAC Congress, Hamburg 1990: (in press)

A.J. Dobbs & N. Williams: Indoor Air Pollution from Pesticides used in Wood Remedial Treatments: Environmental Pollution (Series B) 1983 6 271-96

N. Dudley: Soil Association Report 1984

N. Dudley: This Poisoned Earth: 1987 p. 27

L.P. van Dyk: Hormone Herbicides in the Atmosphere of Natal: Proceedings of IUPAC Congress, Hamburg 1990: (in press)

G. Ekstrom, M. Akerblom: Pesticides: International Food and Water Safety: Rev. Env. Cont. & Toxicol. 1990 114 23-56

Friends of the Earth: First Incidents Report: 1985

Friends of the Earth: Second Incidents Report: 1987

House of Commons Agriculture Committee: The Effects of Pesticides on Human Health: HMSO 1987 (3 volumes) Vol. II p. 293

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: IARC 1987

J. Lohse, S. Winteler et al: Pesticides in the North Sea - A Reason for Concern: Greenpeace International 1990

London Hazards Centre: Toxic Treatments: Wood Preservative Hazards at Work and in the Home: 1989

G. Matthews: Pesticide Application Methods: 1982

M. Mueth, E. Fleischer et al: Volatilaisation of Dithiopyr Residues Following Application to Turf-Grass: Proceedings of IUPAC Congress, Hamburg 1990: (in press)

D. Pimental et al: Pesticides: Amounts Applied and Amounts Reaching Pests: Bioscience 1986 36/2

TGWU/GMB/NUPE Joint Report 1986

US Board on Agriculture, National Research Council: Regulating Pesticides in Food: National Academy Press 1987.

WHO/UNEP Joint Working Group: The Public Health Impact of Pesticides used in Agriculture: 1989

TOXICS AND NUISANCE

CONTAMINATED LAND

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I. INTRODUCTION

When I agreed to write this paper it seemed to me that the meaning of contaminated land was self evident. During the preparation of the paper and the voluminous reading that entails it has dawned on me that the meaning is far from immediately obvious and that, as with so many things, it is important to deal with the semantics at the outset.

Let me ask a series of questions to illustrate what I mean.

Is the sea water contaminated because it is salty? Is it contaminated because it contains the excrement of marine animals? Is it contaminated because it contains the excrement of land animals which has washed out to sea? Is it contaminated because of the excrement of fish in the nearby fish farm? Is it contaminated because of the fertilizer which has washed out to sea from the land? Is it contaminated because it contains untreated sewage which has been discharged to the sea? Is it contaminated because of the wrecked tanker? Is it contaminated because of the oil from the wrecked oil tanker?

There is a gradation in these questions and I would not expect everyone to give identical answers to all these questions.

As a starting point one might start with the 1990 edition of the Concise Oxford Dictionary. This defines contaminate as: to pollute, especially with radioactivity. This did not strike me as particularly helpful, especially as pollute is defined as contaminate. I then turned to the original edition of the Oxford English Dictionary. From this I gleaned the following definition of contaminate: to render impure, to defile.

This I feel is a helpful definition. It has two requirements. The first is that in order to be contaminated the material must have been pure or at least purer. Something which is impure in its natural state cannot be considered contaminated. It is for this reason that I prefer rendered impure to the more frequently seen made impure, since the latter could mean that something which was made impure at the time of creation was contaminated.

This means that two samples of identical composition would be treated differently, a glass of tap water which was salty would be contaminated, but a glass of sea water would not be.

The second requirement is that the impurity should be detrimental. Whether you consider the preservative which has been in your orange juice as contamination will depend upon the view that you take of food additives.

It is well known that in discussing environmental pollution Rylands and Fletcher is frequently mentioned. There is a similarity between the dual requirement for establishing contamination I have set out and the rule in Rylands v Fletcher. The requirements in Rylands and Fletcher are to have brought something onto one's land which was not naturally there and which will cause mischief if it escapes.

II. THE ENVIRONMENTAL PROBLEM

I have said that one of the requirements which needs to be satisfied when we think about contamination is that the impurity should be the cause of some detriment or defilement. The definition of harm set out in Part I of the Environmental Protection Bill is an appropriate test for such detriment. If this were adopted then in order to be considered contaminated, land would need to be the cause of

> actual or potential harm to living organisms, or
>
> other interference with ecological systems of which they form a part, or
>
> in the case of man, an offence caused to any of his senses or harm to his property.

a. Dangers Within the Site

Love Canal in New York State and Lekkerkerk in the Netherlands are both well publicised cases.

At Lekkerkerk 1600 drums of toxic waste from the dyestuffs industry had been illegally dumped on land used for refuse disposal. The land was subsequently reclaimed and 268 houses built on the site. The contamination was discovered in 1980 when the drinking water and underfloor voids had become contaminated with toluene, dyeline and other organic contaminants.

At Love Canal almost 22000 tons of chemical residues were dumped by the Hooker Chemical Company on their property between 1947 and 1953 when the site was capped and reluctantly

sold for $1 to the Niagara Falls Board of Education with the clear warning that the site should not be disturbed by building works. Both a school and houses were built on the site and leachate appeared in the cellars of the houses in 1976.

Both of these cases illustrate the potential problems that can occur with the after use of the site. If the effects of contamination were restricted to the confines of the site itself then the problem of contaminated land would not be severe and the problem would be adequately dealt with by relating clean up to end use, or more precisely relating the further use of a site to the level of contamination. These examples also show the difficulties of managing the situation, first in identifying contamination and secondly in ensuring that having been identified the proper precautions are followed.

It is sometimes said that contaminated sites will regenerate if left to themselves and nature is allowed to take its course. Unfortunately this is not universally true. The Phoenician mines at Rio Tinto still show no signs of regeneration. One does not need to look as far away as Rio Tinto. Amber Valley Borough Council, in Derbyshire, told the House of Commons Environment Committee when they were compiling their report on Contaminated Land that one of their problems was land contaminated from lead mining dating back to pre-Roman times which would cause a public health risk if redeveloped.

b. Dangers Beyond the Site Boundary

Contaminated land may pose a threat to health and the environment either on site or in the surrounding area. This migration beyond the site boundary can occur in three separate ways.

i) Contamination of Neighbouring Land

The contamination may migrate off site so that neighbouring property is also affected by the contaminants. This problem has been recognised and to some extent dealt with in the past by the acquisition of buffer zones around particular plants deliberately so that environmental effects would not be experienced beyond the operating company's property. This is unsatisfactory as a long term solution, given a finite amount of land and increasing pressure for its use.

ii) Water Contamination

The contamination may be washed out into the groundwater or

into surface waters. This presents a serious and often underestimated problem. One of the reasons that contaminated land has been given such attention in the USA, Germany and Holland is the high dependence of the countries on underground water particularly as a drinking water source. This provides a sensitive indicator of ground contamination. In this country we are less dependant upon groundwater as a drinking water source and are often pleased to tell people how many times the water in the River Thames has been drunk before it passes under London Bridge. It is little known how dependant we are upon groundwater, particularly in the South East. Southern Water is 74% dependant upon groundwater as a source of public water supply, Anglian Water 51% and Thames Water 43%.

London well water used to be a source of pride because of its purity. I used to work in Ibex House in the Minories. This building was earmarked in the plans for Operation Sealion as the future SS Headquarters building. Not because of its post-Baulstien tile hung lavatorial architecture, but because it is one of the few buildings in the City of London with its own artesian supply. Sadly London's underground water is now so heavily contaminated, principally with chlorinated solvents, that it is no longer drinkable.

It is true that the contamination can be removed from the drinking water supply by installation of appropriate stripping plants at the point of extraction. However this is an expensive solution and would seem to fly in the face of the polluter pays principle.

iii) Air Pollution

The vapour hazard represents a significant problem when contaminants decompose to form more volatile degradation products.

Landfill gas is the obvious example. This came to the fore as an environmental problem when a house in Loscoe in Derbyshire was blown up in 1986. The explosion was caused by gas which had migrated from a nearby disposal site.

I remember discussing the costs of remedial work at landfill sites with senior DoE Officials in 1986 before this disaster. At the time the view was expressed that the cost of all remedial work at landfill sites in the UK would amount to £8 Million over a 5 year period. Two years later the same Officials were talking of the costs of containing the landfill gas problem as in the region of £350 Million. The first Annual Report of Her Majesty's Inspectorate of Pollution, for

1987 - 88, published in 1989, identifies 602 active and 788 closed landfills with a potential landfill gas problem.

The second annual report of Her Majesty's Inpsectorate of Pollution, for 1989-1990, published in July 1990, reports that the situation is varied with only a few Waste Disposal Authorities and Companies taking the appropriate action. Many are unwilling, or unable, to make the necessary expenditure. The report also states that in some instances planning permission has been granted for inappropriate and unsuitable development of closed sites.

Finally soil contamination may cause harm if the contaminant evaporates and causes an air pollution hazard. I mention this rather reluctantly as it is somewhat obtuse. However it needs to be included for the sake of completeness.

It is also in the same vein as the recent draft guidance notes issued for consultation by the DoE. These deal with processes for control by local authorities who are limited to dealing with air pollution. Yet the guidance notes specify for example that storage tanks should be bunded so as to contain 110% of their contents and that ash from clinical waste incineration should be sent to appropriately licensed waste disposal facilities. While these are manifestly sensible requirements they are only very indirectly addressed to air pollution matters.

c. Biological Contamination

So far I have discussed chemical contamination of land. At this point it is worth mentioning that biological contamination can also be a real problem. The burial of the dead presents special problems. The implications of the disturbance of burial sites of smallpox victims or plague pits are obvious. Special efforts are made for example in the routing of motorways to ensure that such burial places are undisturbed.

These sites tend to be well marked and well known. In contrast many diseased farm animals have for centuries been buried in farm land. These may be, in recent times, animals from herds infected with foot and mouth disease, where carcasses are often burned. They may also in historical terms be animals which died of Anthrax. In the vast majority of cases there is no record of where these corpses may have been buried. The risks of development of are clear and in most cases entirely undocumented.

III. THE LEGISLATIVE BACKGROUND

I hope to have shown that contaminated land is an environmental problem which is a cause for genuine concern. Having done so it is instructive to see the way in which the law deals with the problem.

a. Planning

Until recently the only provisions for dealing with contaminated land lay in the planning system. This was directed to ensuring that the use to which the land was put was compatible with the contamination. When a use was proposed for which the level of contamination was thought unsuitable and posed some threat of harm the planning consent could be conditioned in such a way that remedial work was carried out either prior to or as part of the development. However if no development was planned then the contaminated land could be left untouched.

b. The Water Act 1989

The Water Act 1989 represents a departure from this principle. Clause 115 allows the National Rivers Authority to carry out anti pollution works and operations and to recover the costs from those responsible for the pollution.

This is a distinct change and can be seen as intrinsically fair. However there are several disadvantages in recovering the costs from the parties responsible for the pollution. First of all there is the difficulty of establishing who caused or knowingly permitted the matter in question to be present at the place from which it was likely, in the opinion of the Authority, to enter any controlled waters, or caused or knowingly permitted the matter in question to be present in controlled waters.

Secondly even when the person responsible in this way can be identified it may still be difficult to recover the costs as the entity may either no longer be in existence or may not have the necessary funds.

c. The Environmental Protection Bill

I feel slightly apprehensive mentioning the Environmental Protection Bill. As I am sure you will all know this is still passing through Parliament and is scheduled to have its House of Lords Report Stage completed on 17 October. The Government has introduced amendments to set up a Local Authority Registers of Contaminated Land during The House of Lords

Committee Stage. These are clearly relevant to the issue of contaminated land and I will return to them later.

I would like to restrict my comments to section 58 of the Environmental Protection Bill as it was brought from the House of Commons to the Peers, or section 60 as it emerged from the Committee Stage in the Upper House.

The marginal note mentions the duties of Waste Regulation Authorities as respects closed landfills. However the text of subsection 3 describes three separate circumstances;

(a) land in or on which controlled waste has been deposited at any time under authority of a waste management licence or a disposal licence under section 5 of the Control of Pollution Act 1974, or

(b) land as respects which the authority has reason to believe that controlled waste has been deposited at any time (whether before or after 1st January 1976), or

(c) land in which there are, or the authority has reason to believe there may be, concentrations or accumulations of noxious gases or noxious liquids.

The section specifically exempts land in respect of which a site licence is in force.

In common with several others I believe that this goes well beyond closed landfills and may apply to all contaminated land. Indeed it may even go beyond my earlier definition of contaminated land and include land which naturally contains concentrations or accumulations of noxious gasses or noxious liquids.

The section gives the Waste Regulation Authority the duty to take the necessary steps on the land or on adjacent land to avoid pollution or harm. There is also provision for the Authority to recover costs, except when the authority has accepted surrender of the site licence, from the person who, for the time being, is the owner of the land.

Making the cost of remedial work a charge on the land may seem less fair than the provision under the Water Act to recover the costs from the person who is responsible for the pollution. A new sub-section was added in the House of Lords Committee. This requires that the Authority should have regard to any hardship caused to the landowner when deciding whether to recover the costs and if so how much. This new requirement does away with much of the allegation of unfairness. However, at the same time, it would seem to do

away with much of the likelihood of recovery. It may make the chances of recovery more remote than under the provisions of the Water Act.

Making the cost of clean up a charge on the land as originally proposed is entirely in line with the doctrine of Caveat Emptor. Buyers of land should have regard to its likely contamination. Many already do and my firm in common with others frequently is called upon to perform audits in connection with the acquisition of land. The results of these audits are often important in price negotiations.

I have described a clear legislative trend towards greater powers to deal with contaminated land. It must be pointed out that the creation of powers and duties is one thing, but that their enforcement is quite another. The serious shortages of qualified staff in all the regulation authorities must be a cause for concern that many of the powers and regulations created by the Environmental Protection Bill will be neither used nor enforced.

IV. COMMON LAW PROVISIONS

In addition to describing the position in Statute Law I should also briefly touch upon the provisions for compensation under the Common Law. There has been much talk of strict civil liability for environmental damage of various kinds. Compensation for damage can be dealt with under two separate heads; negligence and the rule in Rylands v Fletcher, which I have already mentioned..

a. Negligence

In English law the tort under which liability for damages usually arises is negligence. The test which is applied is that of the reasonable man, who used to be found on the top of the Clapham omnibus - whether he is still there I suspect is a moot question! In essence, in order to establish liability, there is a requirement to show that a reasonable man, taking proper regard for his fellows, would have acted differently.

b. Rylands v Fletcher

It is often suggested that, at least in this country, and those with a similar Common Law Jurisdiction, the principle doctrine which would be applied to Environmental Liabilities was the rule in Rylands v Fletcher. Some argue that this rule is one of strict liability which lays aside any defence of reasonableness. The rule is stated in Addison's Law of Torts as follows: The person whose mine is flooded by water from his

neighbour's reservoir, or whose cellar is invaded by the filth of his neighbour's privy, or whose habitation is made unhealthy by the noisome vapours of his neighbour's alkali works is damnified without any fault of his own; and it seems but just that the neighbour who has brought something onto his own property [which was not naturally there], harmless to others so long as it is confined to his own property, but which he knows will be mischievous if it gets onto his neighbour's, should be obliged to make good the damage which ensues if he does not succeed in confining it to his own property. But for his act in bringing it there no mischief would have accrued and it seems but just that he should keep it in at its peril, or answer for the natural and anticipated consequences, whether the things so brought be beasts, or water, or filth, or stenches.

This doctrine governs liability at Common Law in cases seeking damages, although it should be pointed out that Scot's Law may not favour the concept of a man acting at his peril and the recent decision in RHM Bakeries (Scotland) Ltd v Strathclyde Regional Council 1985, suggests that the concept may not be applicable in Scots Law. While there is no defence in taking all reasonable steps to contain the mischief, i.e. there is no state of the art defence, it seems to me that there is a requirement that the mischief should be foreseeable and that this is itself a standard of reasonableness.

Environmental Liability

There are a number of developments. One case: W H Smith & Sons v Daw, involves the privy mentioned in Addison's. W H Smith were the tenants of the ground floor and basement of a wing of a building. The upper floors contained five flats. The soil pipe from the flats led down the outside of the building but entered the building at the ground floor. In 1978 a break occurred in the pipe and resulted in the escape of sewage which damaged the premises. W H Smith sued the landlord for compensation.

Judge Fallon found the defendant landlord liable because of the rule in Rylands v Fletcher but rejected any claim in negligence.

The Court of Appeal overturned the original judgement. They relied upon Ross v Fedden (1872) in which it was held that the use of a water closet was natural use of land. As a result the rule in Rylands v Fletcher was inapplicable.

At the appeal the plaintiffs also relied upon nuisance based upon the decision in Border v Salliard (1876). However the Court of Appeal held that the judgement in the Wagon Mound No

2 (1967) required that in Nuisance either negligence or at least fault of some kind is necessary.

Liability for damage or injury as a result of a permitted process is likely to arise under negligence rather than the strict doctrine in Rylands v Fletcher.

If a permitted process is carried out in accordance with permit conditions established by the appropriate regulatory authority it will be difficult to argue that the reasonable man would have done more than follow the conditions laid down by the regulators. There may be special circumstances in which it could be shown that those carrying on the process knew far more than the regulators and so were under a higher duty of care to protect the public. As a result negligence will be difficult to establish when permit conditions are adhered to.

There is a further difficulty in the use of Common Law Torts in the environmental field. In many cases environmental damage does not entail either personal injury or property damage in the traditional sense. This leads to two difficulties. The first is who has the right to sue on behalf of damage to the environment. The second is establishing a quantum of damage: What is the value of the forest or the fish in the river?

At present it seems unlikely that Common Law remedies will be effective in dealing with the issue of contaminated land. This may alter if a new strict civil liability code is enacted, perhaps as a result of a European Community Directive.

Alternatively if a regulated process results in a major environmental disaster it may be thought inequitable that those who were responsible for the process should not be called to compensate innocent victims who have suffered as a result of their activity. I suspect that a major environmental disaster could result in a change in the Common Law, perhaps through a restatement of the doctrine in Rylands v Fletcher.

V. IDENTIFYING CONTAMINATED LAND

It is of course possible to assess a site's likelihood for being contaminated based upon its prior use. The British Standards Institution published a draft for development on the identification of contaminated land in 1988. This discusses such an historical investigation in detail. I do not intend to comment specifically on this process or indeed on other similar suggested schemes.

Environmental Resources Limited conducted a survey of such a

scheme in 1987 for the Department of the Environment and told the House of Commons Environment Committee that integrating the available historical records provides a reliable method of identifying potentially contaminated sites.

There are however fears that such an approach presents risks of blight, questions of confidentiality and financial implications. It is of course a method of identifying potentially contaminated sites rather than contaminated sites themselves.

Although the BSI development draft places much emphasis on end or proposed use, it makes clear the detailed work necessary to establish that a site is contaminated. For example the draft recommends that a 0.5 hectare site destined for use as an allotment should have 15 samples collected from it and analyzed for each of five metals.

It should be remembered that contaminated land can turn up in unexpected places. There is a call for the clean up of several hundred acres of Cornish farm land allegedly severely contaminated with Aldrin residues.

VI. REGISTERS OF CONTAMINATED LAND

In this country there is almost no information about contaminated sites either on a regional or a national basis. This has not been the case in other countries. For example in Western Germany, formerly the Federal Republic of Germany 60 000 altlasten have been identified as requiring clean up under the 'Wasserhaushaltsgesetz'. The total cost estimate is between DM 50 - 100 000 000 000. Of these 1060 sites are as a result of Leaking Underground Storage Tanks and the estimated costs are between DM 300 000 to DM 1 000 000 per site.

We have no similar details of underground storage tank leaks in this country. Indeed the problem barely surfaces as a matter of concern. I recently drove past a garage, still selling petrol but with three boarded up houses around it. I suspect that the cause may have been underground tank leaks. The increasing use of lead free petrol in this country will contribute to the severity of this problem. Lead free petrol, in addition to the carcinogen benzene, has large amounts of tertiary butyl methyl ether added to it. This compound is extremely mobile in the groundwater and enhances the solubility of other organic compounds.

The absence of any collection of information on contaminated sites makes it difficult to asses the overall impact of such sites. The absence of such an assessment of course makes it

difficult to discuss the importance of contaminated land and the issue has tended to be overlooked because of this cycle of disinterest.

I have mentioned that the Government has introduced a requirement for Local Authorities to establish public registers of contaminated land within their areas as part of the Environmental Protection Bill. This is part of the miscellaneous section and places a duty on local authorities to maintain a register of land in its area subject to contamination. The form of the registers are to be prescribed by regulation and none of the detail which the bill contains for other registers is specified. The register is to be compiled from information available to the authority from time to time.

It has to be pointed out that within the meaning of the bill "land subject to contamination" has a special meaning. That is land which is or has been subject to a contaminative use. Contaminative uses will be specified by the Secretary of State by regulation and are uses which may cause the land to be contaminated with noxious substances.

This is obviously a very similar criterion to that used in the waste regulation authorities duty to cause the land in its area to be inspected from time to time to detect whether any land is in such a condition that it may cause pollution of the environment or harm to human health. This includes land in which there are, or the authority has reason to believe there may be, concentrations or accumulations of noxious gasses or noxious liquids.

It does not seem to be effective to give two different authorities different duties concerning essentially the same contaminated land. This must lead to an unnecessary duplication of work.

It would surely be sensible that if one authority is charged with inspecting land in its area which may pose a threat and of carrying out remedial work if that threat is established that authority should also be charged with maintaining a register of such sites in its area.

No inspection or remedial powers are created for local authorities in the section of the Environmental Protection Bill which places the duty on them to create the registers. There are powers, under the Statutory Nuisance provisions of the Bill for Local Authorities for both inspection and preemptive action to prevent nuisance. But these are generally restricted to threats to humans rather than to the environment.

It seems particularly ineffective to give the responsibility of maintaining the registers to one authority with no attendant responsibility for inspecting the land when that responsibility has been given to another authority in the same area.

It has of course been argued that the creation of such registers is likely to have significant impact. At present land values are used for security for many loans. It is frequently said that land is the best security for a loan. The appearance of a parcel of land on the register of contaminated sites may have a significant effect upon its value. This will effect both landowners and the banks who have lent then money against the security of the land.

If land is added to the contaminated land register simply on the basis of data concerning historical use, as is proposed, rather than proven contamination it will be seen as flying in the face of the established principal of English law of a state of innocence until guilt is proved. However there are other areas in the Environmental Protection Bill where a reverse onus of proof is introduced and the merits of a precautionary approach in environmental protection receive widespread acknowledgement.

The occupier of a potentially contaminated site, which has been well managed and so is not in fact contaminated will be forced to go to the expense of demonstrating that the land is in fact uncontaminated but this is not dissimilar to the requirement that a defendant must show there was no Better Available Technique Not Entailing Excessive Cost than the one which was used.

There is no provision for the removal of sites from the Register. The reason is that attention is being given for part of the Register to contain details of any knowledge of the state of the contamination or any details of decontamination which has taken place. The permanent record of this information will prevent land which had been removed from the register being treated as potentially contaminated at some future date when its previous use is rediscovered.

There are two objectives which the proposals for a Contaminated Land Register address in part. The first is to establish a register of all contaminated land and the second is to establish a register of all historical use of all land.

Unfortunately, as the proposals stand, the fact that a particular piece of land is not on the register will not act as a guarantee that the land is free from contamination.

Unexpected land contamination poses an increasing threat to developers and the only way of identifying contaminated sites is a detailed site investigation.

Any registration which is based solely on records of historical use available to the local authority rather than upon physical site inspection may go some way to providing statistical data on the overall picture of contaminated land. However it will not provide reliable data about individual sites which will be of any significant value to either landowners or potential developers or other land purchasers or to the users of neighbouring land or of the groundwater in the vicinity.

VII. REMEDIAL WORK - DECONTAMINATION

Having identified that a particular site is contaminated - in my definition that it presents an actual or potential threat of harm to living organisms or other interference with ecological systems of which they form a part and, in the case of man, includes offence caused to any of his senses or harm to his property - it becomes necessary to carry out remedial action of some kind to remove this threat.

a. Removal

Perhaps the most obvious course of action is removal. The contaminated soil is dug up and transported to a secure landfill site. In other words the contamination is moved from one site where it poses a threat of harm and is moved to another where, because of a different geology it does not. This may seem a less than ideal solution. However while landfill remains the waste disposal route of choice this is likely to remain a common method for dealing with site contamination. It is of course an improvement on the practice of simply covering over the contamination, either with tarmac in order to make a car park, or as I first saw happen over fifteen years ago with fresh soil in order to disguise the existence of contamination.

b. Off-Site Treatment

A second, and rather more sophisticated course of action is to remove the contaminated soil and treat it in some way. This may be done by incineration, or rather by roasting, where the excavated soil is subjected to high temperatures in an oxidising environment in which the contaminant is burnt off. This method tends to produce an inert ash like soil as all the natural organic components of the soil tend to be destroyed at the same time.

The excavated soil may be subjected to chemical or biological treatment to destroy the contaminants, for example by land farming.

However such excavation and off site treatment is intrusive requiring considerable earth moving which may itself disrupt the underground water and if long transportation is involved may create its own environmental hazards. An alternative approach is the treatment of the contaminated soil in situ.

c. Pumping

In some instances where the groundwater is contaminated, or where an immiscible layer is lying above it, this can be removed and treated by direct pumping of the liquid. The extraction of the groundwater will create a cone of depression which will contain any contamination floating on the groundwater and prevent its escape and more widespread contamination.

d. Air Stripping

The air stripping process is often used for the removal of volatile organic compounds from contaminated groundwater. As the name implies the volatile compounds are transferred from the liquid to the vapour phase. This is a relatively simple system and depending upon the nature of the contaminants can provide a cost effective system.

e. Soil Vapour Extraction

Where the contaminated soil is not saturated with water the air stripping technique is not suitable. In these circumstances a simple vacuum extraction technique applied to a small number of bore holes can generate the air flows necessary to remove volatile organic contaminants.

This relatively simple technique can be supplemented for example by a steam extraction technique. Steam is injected into the boreholes and acts to volatilise the organic contaminants in the steam distillation process. Some developments of this technique include the use of large auger bits which create intimate mixing of the soil. It may also be possible to introduce reagents to react with particular contaminants.

In all cases of vapour extraction it is necessary to consider the treatment of the gasses. If these are harmful then simply discharging them to air may be inappropriate. The gasses may need to be collected and treated or destroyed. Various methods including the use of plasma torches have been

investigated for such destruction. There has even been a suggestion that such a plasma torch could be created on the trailing edge of a rotating auger bit to destroy volatile organics in the ground with out extraction.

f. Bio-Remediation

The goal for effective treatment of contaminants in-situ without the need for expensive collection, containment and destruction has great appeal. There is an assumption that left to itself nature will recover given sufficient time. Although as I have mentioned this is not always the case there is some validity to this assumption. The validity is based upon the destruction of contaminants, particularly organic contaminants by micro-organisms. Micro-organisms are capable of utilising a very large variety of carbon sources. As an example bacteria can be induced to metabolise the anti-biotic penicillin. They are therefore capable of degrading almost all organic pollutants.

The reason that some organic contamination is long lived is that the correct conditions do not exist for the rapid utilisation of the contaminant as a carbon source. This may either be because the optimal conditions for microbial destruction do not exist, or because the appropriate organisms are not present in the soil at the site of the contamination. Bio-remediation technology is based upon the creation of these optimal conditions, either by the inoculation of the soil with bacteria capable of utilising the contaminant as a carbon source, or the optimisation of the conditions to facilitate the microbial decomposition of the contaminant.

Some of the techniques proposed for soil decontamination sound like science fiction and several of the techniques which I have mentioned along with many others are still at the development stage. In deed many will remain at the development stage in part because no two contaminated sites will present either identical contamination or identical soil and hydrogeological conditions. As a result individual sites will need to have decontamination schemes custom designed for the individual site conditions.

VIII. STANDARDS FOR DECONTAMINATION

I have offered a definition of contaminated land as posing an actual or potential threat of harm. By implication of course this means that the standard for clean up is the removal of that actual or potential threat. This, I am well aware, can be criticised as it does not give any absolute standards. That a site containing a certain ppm of a particular contaminant is contaminated and the removal of the contaminant

to below the threshold concentration constitutes clean up. Unfortunately science or nature is not as neat and tidy as that. What constitutes a threat of harm will vary from place to place depending upon a whole range of factors. This is of course the reason that it is possible to consider the removal of contaminated soil to secure landfill as a method of clean up.

It is naive to attempt to side step the contentious question of how clean is clean. This will be a major issue in addressing the question of contaminated land. However this is as I have indicated very close to the question of how dirty is dirty. I have chosen to define contaminated land using language from the Government's Environmental Protection Bill. This leaves open the question of what constitutes an actual or potential threat of harm.

There is an understandable urge to adopt the check list approach. While this has the appearance of simplicity this simplicity is entirely misleading. I recall that at a Conference discussing low probability high outcome events, shortly after the Bhopal accident, it was suggested by one of the lawyers present that all one needed to do was to check a plant's inventory against the substances on the Seveso List in order to perform a hazard assessment. He was somewhat shaken when I pointed out that Methyl iso cyanate was not on the list.

IX. THE BURDEN OF CONTAMINATED LAND

There have been a number of studies which predict that there are in the region of 50 000 to 100 000 contaminated sites in the country possibly affecting in excess of 50 000 hectares. Only a small proportion of these sites will pose an immediate threat to the environment or human health. I do not intend to offer any alternative estimates to these.

The potential cost burden of these sites is difficult to assess.
I have already quoted the German estimates for the costs of remedial work which averages at perhaps DM 1.5M per site. The clean up of the Lekkerkerk site in Holland cost £156 M, while the Office of Technology Assessment of the US Congress has suggested that the total cost of clean up in the United States could be $500 billion. Rather more than the estimate of $250 billion which I put forward in 1982 which was thought to be wildly exaggerated.

I do not propose to make a corresponding prediction for sites in the UK. In part because any such prediction can only be imprecise. What is clear is that the potential cost is very

substantial. As the Minister for the Environment and Countryside said at a recent meeting I do not know how the Government will manage the substantial costs of contaminated land without the 7:1 gearing of the Derelict Land Grant.

It has to be pointed out that the results of a disperse and dilute policy if unsuccessful is to increase the eventual cost of decontamination. By way of example a stripping tower will remove c. 99% of volatile organic contaminants in a single pass regardless of the concentration of the contaminants. As a result treatment is cheapest when the contaminant is most concentrated and before dispersal and dilution has taken place. If treatment of extracted groundwater is required before it can be used for drinking water then the costs of decontamination over time will be greatly in excess of the costs of decontamination carried out at the site of contamination before dispersal had taken place.

The massive potential burden of contaminated land means that prudence is called for in setting clean up standards. If this is not done the burden will be intolerable. It is really essential to set priorities. We need to ensure that all those sites which do pose an actual or potential threat to the environment or human health are given adequate remedial work to remove that threat, but that sites which do not pose such a threat are monitored in an effective way but not subjected to expensive clean up until such a threat materialises.

X. REQUIREMENT TO PREVENT FURTHER CONTAMINATION OF LAND

It follows from what I have said that we may have to live with much of the contaminated land which we have because its wholesale cleanup would simply be too expensive for us to afford.

In any event it should be clear that the costs of preventing the contamination of land are considerably smaller than the costs of subsequent remedial work. As in many other areas prevention is preferable to cure.

It is of course true that the costs of remedial work or of compensation through some strict liability regime will act as a deterrent. However this does suffer from a number of drawbacks as I have mentioned.

Since the objective is to prevent the contamination of land, rather than to clean up the contamination after it has occurred it may be more effective to impose stringent criminal sanctions against those contaminating land rather than a strict liability regime for damage and clean up.

In this connection it is interesting to note that the Environmental Protection Bill introduces a number of strict criminal offenses with no limitation as to who may bring prosecutions. For example there is to be an implied condition of every authorisation under integrated pollution control that the operator shall use the Best Available Techniques Not Entailing Excessive Cost to minimise and render harmless the release of every substance which might cause harm to the environment, and in the case of a prosecution places the operator under a reverse onus of proof to show that there was no better technique than the one he used.

This provision, of course applies to the contamination of land, in my definition, caused by a process subject to integrated pollution control. This could be extended to all contamination of land and if this was done would provide a more effective deterrent.

TOXICS AND NUISANCE

THE FUTURE FOR DIESEL ENGINE EMISSIONS AND LEGISLATIVE CONTROL FOR THE 1990S

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Introduction

Now that the form of the EEC emission controls for petrol engined vehicles is essentially resolved, legislative attention is now, at last, moving to control diesel emissions. The United States has had diesel emission controls for several years and is now moving towards increasingly severe, staged levels of control for 1991 and 1994. The 1994 standard is very severe indeed and will require very substantial modifications and controls not only of engines but fuels as well. In this paper, I will explain the intrinsic nature of the diesel emission problem and how it may be overcome for the various stages of reduction intended. I will also emphasise that legislation is but one stage towards pollution control, there must be effective enforcement as well, which would be best undertaken by local authorities.

This paper continues on from, and is very much related to, the excellent papers given to the 1989 NSCA Conference by, first, Edward Betts of Esso[1] on vehicle emission controls and, second, Sonja Boehmer-Christiansen on evolving European legislation on emission controls[2]. The National Society for Clean Air and Environmental Protection has also promoted its "Dirty Diesels" campaign in the interim period.

I will discuss the problems of diesel engine combustion faced by original equipment manufacturers (OEMs) in meeting the current US-EPA 1991 and 1994 emission requirements and the proposed EC emission legislation from the viewpoint of an international market. The importance of enforcement procedures to bring about a real improvement in on-road operation emissions will be emphasised. The proposal for methanol as a substitute fuel for diesel engines will be critically examined.

Operation of a Diesel Engine

Whilst most people have some understanding of a petrol engine from personal experience, equally most people do not understand how a diesel engine works. Not only is the principle of operation different, under the general heading of heat engines, but also the scale of forces and chemical kinetics are different. It is essential to understand the

diesel cycle first so as to understand the problem of diesel emissions second.

The diesel engine is a compression ignition engine, that is, the heat of compressing air very rapidly without thermal equilibrium with its surroundings will ignite fuel sprayed into it at the right moment. Air is drawn into the engine by the receding piston through the inlet valve and then compressed adiabatically by the ascending piston with the valves closed (Fig. 1). The temperature of the air charge will rise to about 500°C with typical pressures of 30-40 bar. Just before the piston reverses at the top of the stroke, fuel is injected as a high pressure spray. The spray can either be a single or multiple jet, directed either into an auxiliary chamber ("indirect inection" or IDI), Fig. 2, or directly into the combustion chamber ("direct injection"), Fig. 1. Diesel fuel is not very flammable en masse and requires time to burn, being less volatile than petrol or paraffin. I hope to show this process in a high-speed photography film sequence.

The fuel spray has to penetrate a high density, high pressure and high temperature air mass. The fuel must be broken into very fine droplets ("atomised") and allowed time to burn in a high temperature, turbulent, air mass (Fig. 3). The higher the temperature and the longer the burning time, the less carbon particulates will be formed and emitted. These are, however, the ideal conditions for formation of nitrogen oxides, NOx. The simultaneous reduction of particulate and NOx formation is, on thermodynamic and kinetic grounds, mutually exclusive and other means must be used to reduce them at the same time. This is a formidable problem which requires a considerable research effort. One major US manufacturer claims to have spent $200M per year for the past five years on particulate and NOx reduction for emission controls for the 1991 and 1994 standards.

DI diesel engines are more efficent that IDI engines because of their reduced thermal loss to the cylinder, the removal of pumping losses from the auxiliary chamber of IDI designs and an enhanced combustion rate. Against that, DI engines tend to be noisier because of the increased rate of pressure rise and have increased emissions of both particulate and NOx compared to IDI engines. Therefore, IDI engines have been preferred for light vehicles and DI engines for medium and heavy road transport vehicles where internal noise and vibration is not regarded as such a problem. However, DI engines are being introduced into the light vehicle market, examples being the extraordinary Prima engine in the Montego which gives either 100 mpg or 100 mph (but not both together) and the Ford Transit van.

For both types of injection engine, the emission problems of the diesel engine can be compared with those for petrol engines as:

- less nitrogen oxides, as NOx
- much less carbon monoxide
- less hydrocarbons, including VOCs, but
- much higher particulate levels

The current and proposed emission control legislation concentrates upon NOx and particulates. Whilst diesel emissions of NOx are less than from an uncontrolled petrol engine, they are much higher than the emissions from a petrol engine equipped with a catalyst. Hydrocarbons, in the petrol engine sense, are not a direct problem because of the much lower volatility of diesel fuel but appear as carbonaceous particulates produced by incomplete combustion instead.

Reduction Technology for Diesel Emissions

Taking a naturally aspirated diesel engine as a baseline of 100% for particulate emissions, turbocharging the engine with intercooling produces an emission reduction of about 40%, and this is well established technology. More sophisticated control of the injection process, by taking into account the engine speed, condition, perceived load, etc, by reference to a performance/load map held in an electronic engine management system, can lead to a further decrease of 25-30% in particulate emissions.

When reductions are achieved in one process, in this case combustion, the contributions from other, previously minor processes, become increasing important. Particulates formed from lubricating oil entering the combustion chamber from the sump, via the cylinder piston ring pack, was a significant but minor contribution in the past. As particulate formation in the combustion chamber is reduced, then the contribution from the lubricating oil becomes increasingly important.

Diesel lubricating oil is formulated to deal with the high (relative to petrol) sulphur content of diesel fuel, controlled at present to 0.3%. The sulphur produces acids which must be neutralised or the engine will be corroded. The lubricating oil is a much heavier hydrocarbon fraction which will itself produce particulates on combustion. The anti-acid component of the additive pack in the oil will produce particulates, but a different type than the carbon particulates. But in the emission control analysis, all particulates count.

Therefore, two routes must be followed to control lubricating oil-based emissions, first, a design change to the piston ring pack which allows less lubricating oil to enter the combustion chamber. This must be achieved while at the same time ensuring that the top end of the bore is properly lubricated to reduce engine wear. However, in the longer term, as engines begin to wear, this will lead to increased emissions and set out a marker for on-the-road enforcement of emissions from worn engines.

But, second, the anti-acid particulate emissions can be significantly reduced by a move towards a reduced sulphur fuel, typically 0.05% sulphur. This is already marketed as "clean diesel" in the western USA and is foreshadowed in the proposed EEC legislation. These are readily realisable internal modifications to diesel engines for the reduction of particulate emissions. Other internal modifications would be redesign of combustion chambers/piston bowls for more efficient combustion, higher pressure fuel injectors up to 20,000 psi to atomise the fuel charge more and reductions in the fuel volume in those injectors. These measures may give a further particulate reduction of 10% on the original scale of the original, naturally aspirated, diesel engine. But keen observers will already note that we are into the realms of diminishing returns.

External means of reducing particulate emissions centre around the particulate (exhaust) trap. Various designs exist, generally based upon a tortuous path for the exhaust through a complex collector or trap. Some traps have a catalytic function, which burns off the particulates as they are collected. The problem is that diesel particulates are not (relatively) simple hydrocarbons with, again, a relatively simple oxidation mechanism. Sulphur in the fuel will poison the catalyst and must therefore be reduced, another argument in favour of low sulphur (0.05%) diesel fuel. The alternative is to periodically reactivate/oxidise the particulate trap by plugging built-in heaters into the electrical mains. The market acceptability of such a solution has yet to be demonstrated.

Whilst these soluions for the reductions of particulate emissions from diesel engines are very viable, the real problem is to achieve them at the same time as reducing nitrogen oxide, NOx, emissions. The majority of the solutions set out above will effectively reduce particulates by more thoroughly oxidising them. These are the very conditions which will produce higher NOx emissions at the same time. Therefore, NOx formation is reduced by delaying the injection of the diesel fuel more towards the Top Dead Centre position of the piston, ie retarding the fuel injection. The direction

of the fuel injection is oriented more towards the wall of the combustion chamber/piston bowl. The retarded/redirected fuel injection balances the previously described measures to reduce particulate emissions with the reduced nitrogen oxides, NOx, emissions. These are the basic modifications to meet the 1991 US-EPA emission standards for both particulates and NOx. But to achieve the 1994 emission standards requires an enormous amount of further work, sufficient for one US OEM engine manufacturer to set up an internal "Task Force" for this purpose. Nevertheless, OEMs are sure that the US-EPA 1994 Regulations are achievable soon. It is worth remembering that the 1991 US-EPA Regulations requirements could be met by most OEMs pre-production engines in early 1989.

The International Diesel Engine Market

The worldwide diesel engine market is more universal than the petrol engined vehicle market. It is interesting to note that European diesel engined vehicles are gaining an increasing share of the North American market, by both export to and US manufacture within, of European designs. In contrast, US diesel engines have a strong European market in off-road vehicles, primarily in earth-moving vehicles, but much less so in road vehicles. The penetration of US diesel engines into European road vehicles is growing at a slow rate but is increasingly successful in railway units and locomotives.

Whereas US diesel engine manufacturers operate alone, European manufacturers increasingly co-operate in consortia, either by common design or by joint research program approaches to common problems. There is, as always in Europe, one significant exception. But the important point is that European diesel engine manufacturers, either collectively or singly, operate successfully in the North American market and must necessarily resolve the emission control problems posed by the 1991 and, particularly, the 1994 US-EPA Regulations, to stay in business. Almost all of the significant European diesel engine manufacturers can already meet the 1991 Regulations and are now looking at the formidable task of meeting the 1994 Regulations.

We therefore have a potential re-run of the petrol engine emissions problems vis-a-vis the USA and EEC. Then, for petrol engines, as now for diesel engines, the major European manufacturers can meet the immediate US 1991 emission control Regulations which are well in advance of European proposals for possible Regulations. Given the necessary time to introduce manufacturing changes, the Best Environmental Timetable approach, there is no reason why the EEC diesel emission control proposals should lag so far behind the US-EPA

Regulations already in place and to be complied with in the immediate future.

One reason for the different timetables for the US and European diesel emission control Regulations is the different approach used. The US approach is based upon "technology forcing", where the legislature sets the objectives and the relevant industries have to comply, with many legal representations on the way. The environmental timetable is set and industrial technology has to meet its demands - the solution to the issues is forced. This approach can be seen operating throughout the US petrol emission control program since 1964. However, in Europe, the relevant industry is extensively consulted, complicated by national interests, and the pace set tends to be that of the slowest or the most technologically underdeveloped. The technological advance to solve environmental problems is thus not forced. Fig. 4 shows a timetable for the established US and proposed EEC diesel emission standards and illustrates the long lag between them.

The Increasing Need for Effective Enforcement of Diesel Emissions

The techniques for reduced diesel engine emissions which have been described previously represent an optimised situation of a complex problem. The general representation of an optimised solution to a varying one dimensional input is shown in Fig. 5. When the input varies, then the optimisation deteriorates rapidly. The greater the optimisation, as an upside benefit, then the greater the benefit obtained. But equally, when the inputs vary for a highly optimised solution, then the greater the deterioration, Fig. 5. This general principle can be applied to many quasi-optimised systems. The UK motorway system is one such case, where extensive optimisation techniques have been applied to plan the network, such as it is. Equally, when there is an unplanned event, such as an accident, then the road system's performance deteriorates and disruption is equally optimised.

The application of this concept to the reduction of diesel engine emissions follows equally forcefully. If diesel emissions are to be reduced by the delicately balanced optimisation of particulate and NOx reductions through fuel injector design modifications and piston ring design changes, as two examples of possible reduction techniques, then injector fouling and ring pack wear will rapidly increase emissions in the service life of the engine. Therefore those emission reductions must be maintained for a long engine service life but when deterioration happens, the increased

emissions must be picked up rapidly. Local authorities, given sufficient powers and resources from central government, are best placed to control diesel emissions in the Australian manner, as described to the NSCA Parliamentary and Local Government and Technical Committees[3].

In petrol engine emission control legislation, it has been implictly assumed that old, uncontrolled or lesser controlled emission engines would be scrapped together with their original car/light van when the vehicle was no longer viable, for a life of between 10-15 years. New vehicles with better emission controls would then gradually take over the vehicle population and, hopefully, emissions would decrease. The vehicle diesel engine situation is quite different. The engines are used more extensively and overhauled several times in their long lifetime and refitted into different vehicles.

The different pattern of use and renovation for diesel engines means that emission compliance certification should go with the engine rather than the vehicle. It also means that reliance upon the natural turnover of vehicles to increase the percentage of the engine population which have good emission standards will give a slow improvement. We must therefore urge the EEC to consider a subsidiary set of emission standards for existing, older engines which are achievable by retrofitting equipment at an engine rebuild. If this measure is not included, then the overall reduction in diesel emissions will be only slowly perceived.

Other Emission Control Solutions

The Raprenox Process[4]

A very new and effective treatment for the removal of nitrogen oxides from any combustion process, including diesel exhausts, is the Raprenox Process. Iso-cyanuric acid is generated in a separate apparatus and introduced into the exhaust gas stream. The reaction is very rapid and complete:

$$HNCO + NOx = H2O + CO2 + N2$$

This process has been shown to be very effective in reducing NOx emissions from a stationary 50kW diesel generator set by 95% with no residual iso-cyanuric acid detectable in the exhaust. The current problem is to reduce the size of the acid generator such that it can fit onto a large freight vehicle without taking up a disproportionate amount of space.

The important aspect of this process is that it decouples Nox emission control from particulate emission control.

Previously, both had to be accomplished at the same time frame within the combustion chamber. The Raprenox process enables particulate emissions to be minimised separately and meet the Regulations within the combustion chamber while NOx emissions are very effectively dealt with downstream in the exhaust system. The process certainly works and now needs to be decreased in size such that it can be readily and reliably used on a freight vehicle.

Methanol as a Diesel Fuel

Methanol has been proposed as an alternative fuel, together with ethanol and either liquefied or compressed natural gas. Extensive major trials, as against short term minor trials are about to begin in the USA under the Alternative Fuels Act, 1988[5]. These trials are oriented towards the use of diesels in inner cities, particularly for buses. The bus driving cycle, of frequent idling, hard acceleration, cruising followed by deceleration and idling, is one of the toughest cycles yet devised for the life of the engine, the lubricating oil and emissions.

Methanol is a clean burning diesel fuel with reduced NOx emissions. These emissions can be reduced further by modifications to the combustion process so as to meet the 1994 US-EPA Regulations. It is my view, however, that the use of methanol as an urban vehicle diesel fuel has many more disadvantages than advantages.

Methanol has a lower flashpoint than conventional, DERV, diesel fuel and is much more volatile. It is therefore much more of a fire hazard. Because of its lower energy density, twice the volume of methanol must be carried for an equivalent travelling range than DERV fuel. Methanol is a toxic hazard when its varpour or liquid is absorbed into the body, its metabolites first attacking the optic nerve to cause blindness and then death. It is also much more corrosive than DERV, particularly when wet - it absorbs water strongly and continuously. Methanol degrades current lubricating oils very rapidly and gives up to a factor of ten in increased engine wear. It is not compatible with DERV except to a very small extent and a completely separate fuel storage, transport and delivery system system must be duplicated in corrosion resistant materials. A new catalyst system must be developed to reduce the emitted aldehydes, produced from the incomplete combustion of methanol, which will otherwise accelerate photochemical smog formation.

Methanol as a diesel fuel has so many adverse factors that I am surprised that the consumer, public/environmental protection bodies have not campaigned against it so far. The

point has to be made that methanol production technology is based within the chemical industry and outside of, and separate from, the petroleum industry. But most methanol is made from natural gas by a catalytic process. Energy conservation considerations alone would point to the use of natural gas direct, either compressed or liquefied at low temperature.

Conclusions

The time has now come for road diesel engine emissions to be controlled. There is no need for the EEC proposals to lag so far behind those of the US-EPA because of the international market in diesel engines. The EEC should not seek a uniquely "Euro-solution" because the US-EPA emissions standards are achievable and a significant step towards reducing emissions overall. Most European manufacturers are able to meet the 1991 US-EPA Regulations for sales to the US and, no doubt, will meet the 1994 Regulations in due course so as to continue those sales. The sulphur content of diesel fuel will need to be reduced from the current 0.3% to 0.05%, to give many other benefits as well. European manufacturers could therefore meet the proposed EEC Regulations without great delay.

An essential part of any emission reduction control strategy is enforcement and local authorities' environmental health departments, suitably resourced by central government, are ideal for enforcing reduced diesel emissions. Certification of reduced emissions should go with the engine. Subsidiary standards for older, rebuilt engines, should be considered, otherwise reductions in diesel emissions will be very slow. The proposed use of methanol as an alternative diesel fuel should be considered from a health, fire and safety viewpoint.

REFERENCES

1. "Prospects for Engine Design and Engine Technology", Edward Betts, p.57, 56th NSCA Conference Proceedings, 1989, NSCA.

2. "Evolving European Legislation: The Demise of Lean-Burn and the Polluter Pays Principle", Dr. Sonja Boehmer-Christiansen, p.65, 56th NSCA Conference Proceedings, 1989, NSCA.

3. Information Bulletin from the Environmental Protection Authority, Victoria, Australia, quoted by the NSCA in papers to the Technical and Parliamentary and Local Government Committees, June, 1990.

4. "Status of the Raprenox Afterteatment Scheme for Diesel Engine NOx Reduction", Ralph Slone, Proc. 1990 "Coatings for Advanced Heat Engines Workshop", Castine, Me, August 6-9th 1990, publ. US DoE.

5. "The Alternative Fuels Demonstration Program", Steve Goguen, ibid.

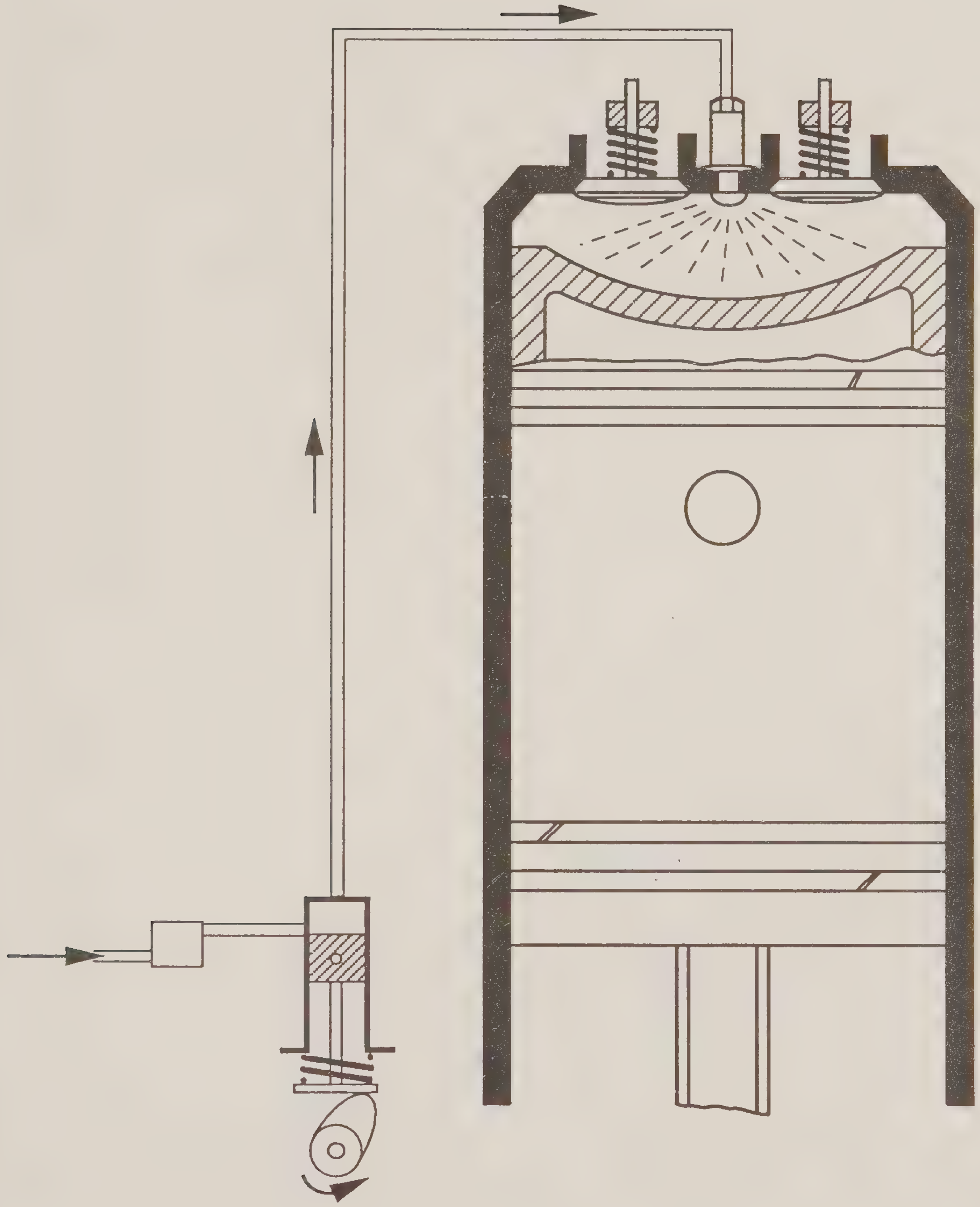


Figure 1. The Direct Injection Engine

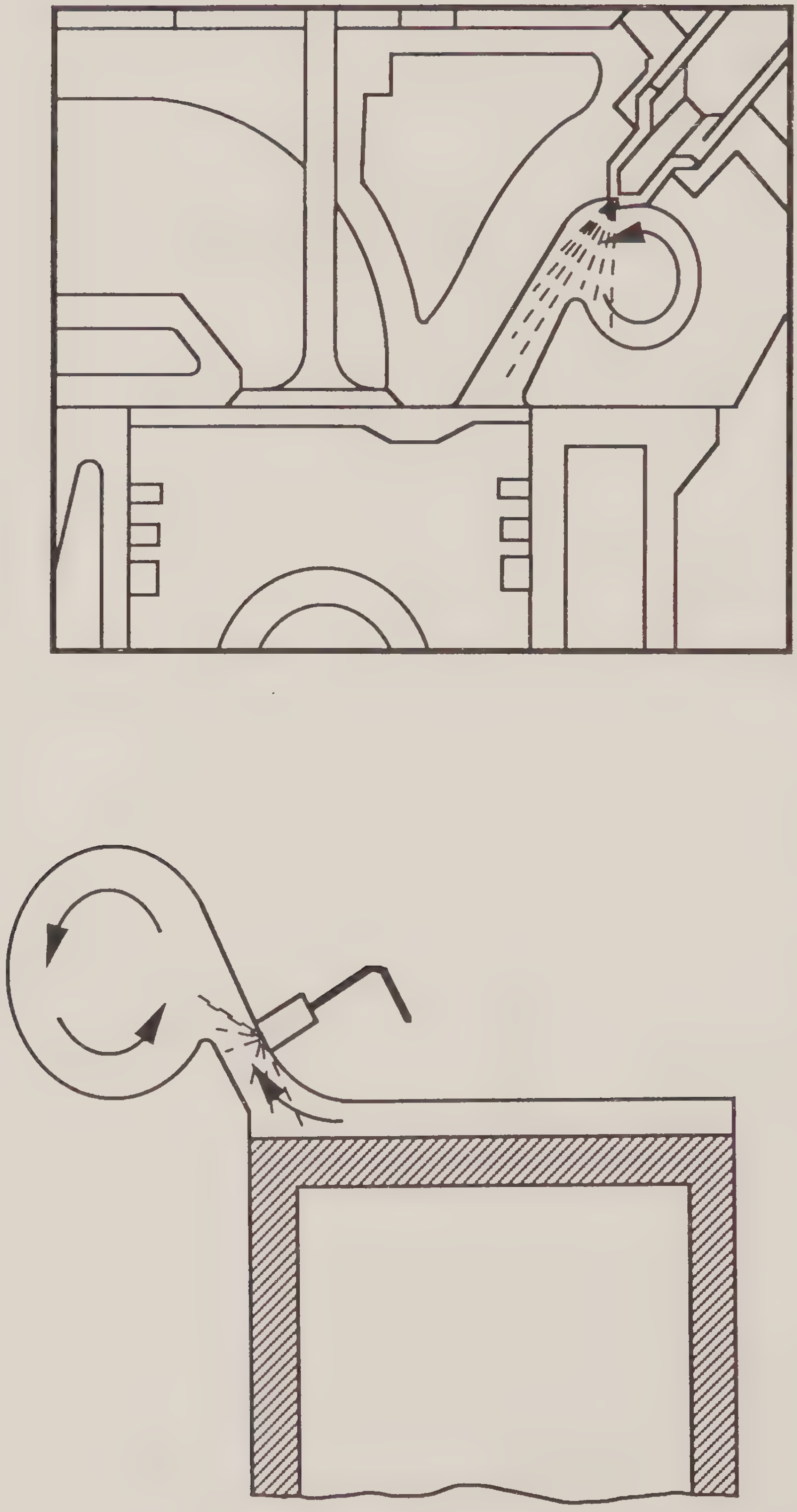


Figure 2. Types of Indirect Injection
Diesel Engine Cylinder Heads.

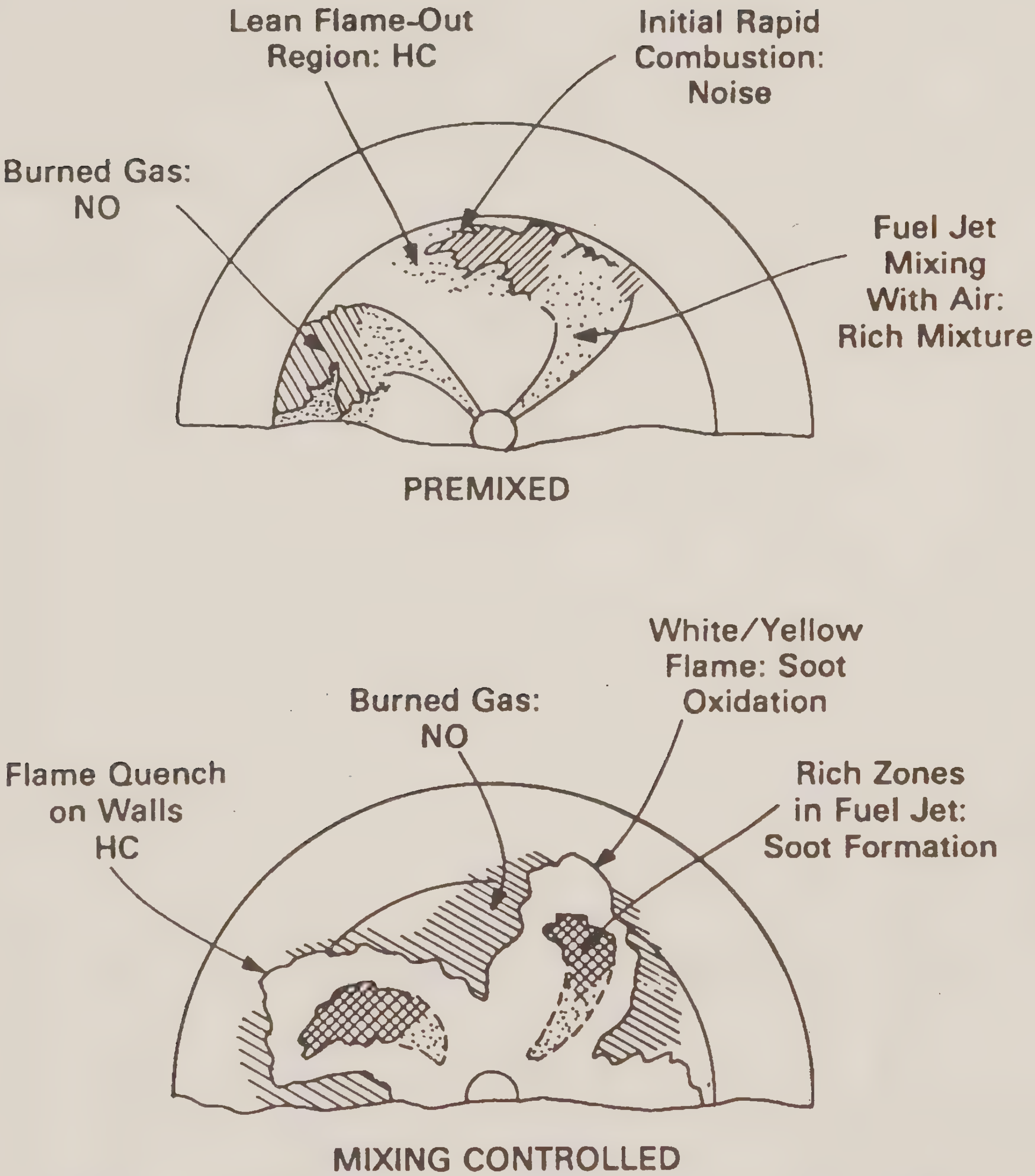
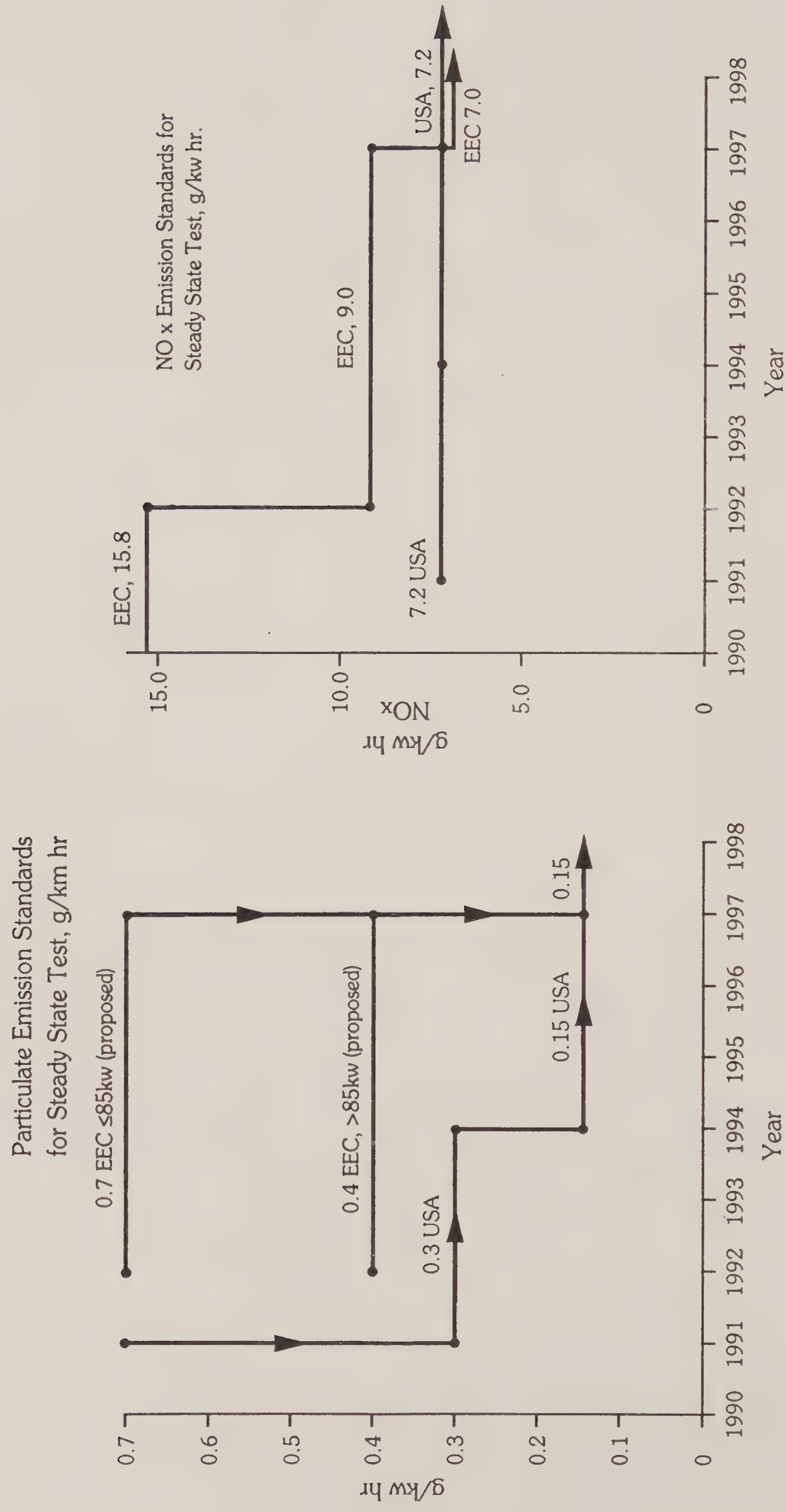


Fig 3. Schematic of direct-injection compression-ignition engine combustion process during the initial "premixed" rapid combustion phase and subsequent "mixing controlled" slower combustion phases.

Figure 4.



Values given are Conformity of Production (COP) Standards

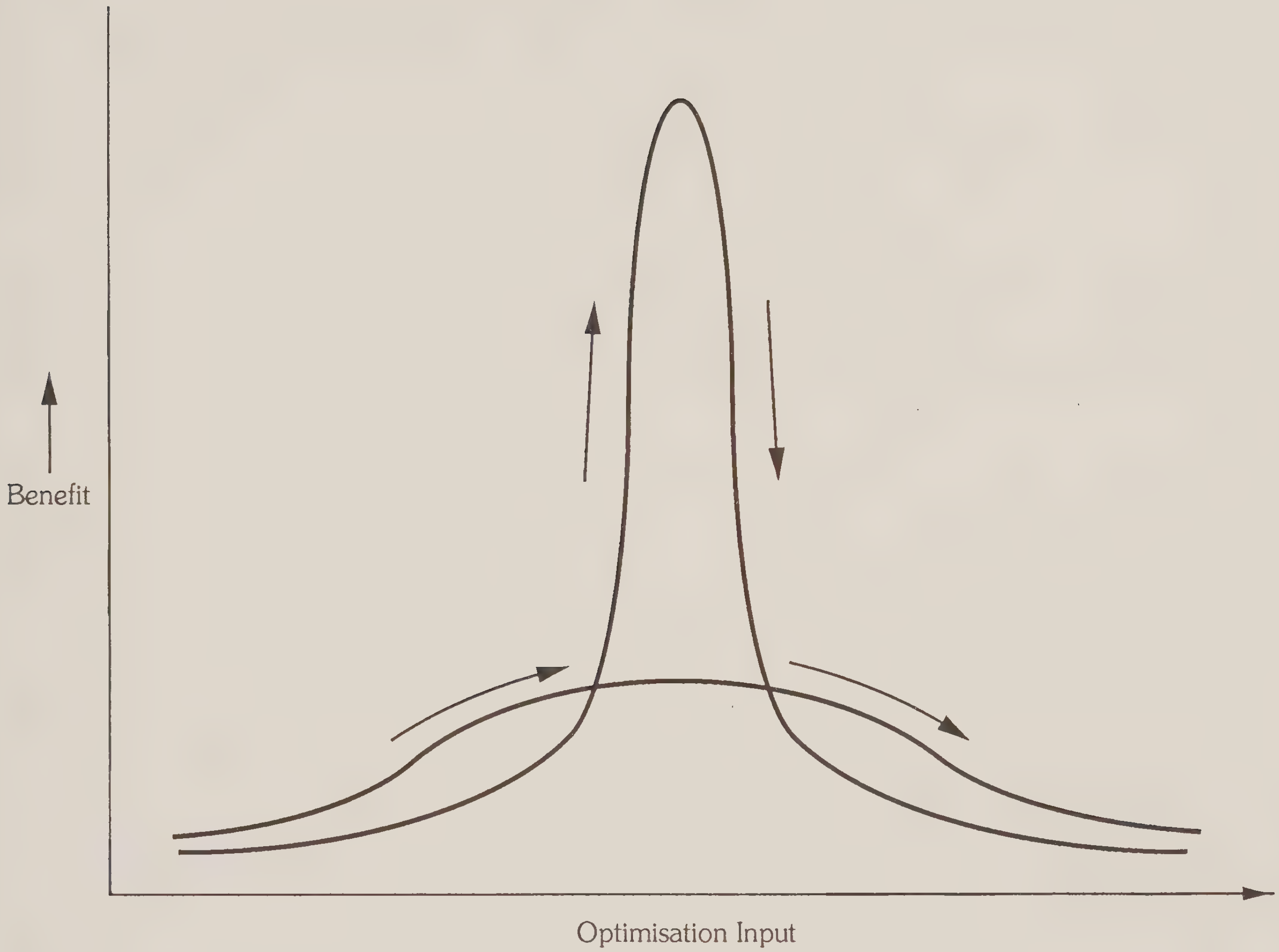


Figure 5.

TOXICS AND NUISANCE

ENVIRONMENTAL PROBLEMS ASSOCIATED WITH LARGE COOLING TOWERS

N. Parkinson
Selby District Council

INTRODUCTION

Large natural up-draught counter flow cooling towers (Fig. 1) using untreated water enable industry and particularly power stations to operate in areas where the local water supplies can only provide a small proportion of the cooling water requirements.

In the mid 1970s there were over 300 large natural draught cooling towers in operation in the United Kingdom. Today there are believed to be 120 towers in operation, mainly controlled by the electricity supply industry, but this number will probably be reduced following privatisation of the Central Electricity Generating Board (CEGB). The large bulk of the tower is generally regarded as creating an adverse visual effect and this is exacerbated on occasions by the large persistent plumes emitted from the cooling towers.

Initial environmental problems associated with the operation of large cooling towers included:-

(a) The visual impact of the tower and associated plumes.

(b) The alleged thermal pollution caused by the discharge of the cooling water to the local rivers.

(c) The emission of water aerosols from the top and base of the cooling tower can lead to icing of nearby roads in freezing conditions.

These problems have been investigated and to some extent reduced by the electricity supply industry over the years but specific site problems apparently still occur.

More recently, with the completion of the Drax 4,000 MW power station in Selby District, North Yorkshire, with twelve cooling towers, there have been further complaints alleging that water vapour and droplet emissions from the increased number of cooling towers is causing a loss of sunlight in the area and in some instances an alleged reduction in crop yields. These complaints at Drax have not been investigated by National Power to date. Preliminary observations by Selby DC Officers indicate that a comprehensive investigation is

justified.

In September/October 1989 a prolonged drought caused a substantial increase of suspended solids (SS) in the local River Ouse which is used for make up on the cooling tower water system at Drax Power Station. It was known that the local river water and silt were polluted with untreated sewage effluent, some of it discharged from the local works. Unfortunately, because of long term deterioration in river quality and drought, the station's cooling water settlement and sedimentation system was inadequate for containing the very high level of suspended solids in the river water. The station was designed to accept 10,000 ppm of silt in the river. Ultimately all 12 cooling towers at Drax were emitting silt with the water droplets onto the local villages. In addition, the plastic water droplet (Drift) eliminators which were on trial in one cooling tower collapsed with the weight of suspended solids, and this resulted in substantial quantities of contaminated river water and silt being deposited on local villages. The emission of contaminated silt continued for eight days before the cause was identified and remedial action taken. The incident caused much local concern and anxiety, and resulted in many queries concerning the potential health hazards associated with the possible emission of micro organisms from power station cooling towers under specific conditions. The possibility of the emission of legionella and other organisms with the drift of aerosols from the top of cooling towers has been queried several times in recent years. Unfortunately, no definitive data on this topic has been published for power stations in the United Kingdom. These potential problems will be discussed in more detail.

DESCRIPTION OF COOLING TOWERS

Basically a natural draught cooling tower (Fig 1.) consists of an hyperbolic shaped shell of reinforced concrete forming a chimney, which in a large power station, typically, would be approximately 114m (374ft) high with a top diameter of 52.6m (173ft) and a pond diameter of 95.2m (312ft). Each tower would have a shell thickness of 178mm (7"). At Drax Power Station in North Yorkshire each tower is initially designed to cool 9.4m^3/second (7.45 M/gallon/hr) of water from 30.5^o centigrade to 20^o centigrade (Drax Power Station).

The cooling water is pumped to a height of approximately 23m, distributed by a spray system and flows down through a heat exchange packing (wood or plastic), whereby with the combined effects of evaporation and conduction, heat is transferred to the air which flows up through the shell of the tower. In general about 80% of the cooling occurs by evaporation and

about 20% by sensible heat transfer (B.S.4485 Part 3 1988). An eliminator (Fig 1) is located above the heat exchanger to screen out the small droplets of cooling water which would otherwise be carried up in the air stream and deposited as droplets of rain (river water) in the local area of the towers. To facilitate free ingress of air at the base of the cooling towers the shell is supported on legs which are so inclined as to resist the sheering force of the wind on the shell of the tower.

The function of the heat exchange pack (Fig. 1) is to increase the surface area between the warm water and cooling air. This is achieved either by breaking the water up into fine droplets, as in the splash packings which have often been used in large cooling towers, or by providing a large area over which the water runs in a film as in the film type packings. The circulating water can be distributed over the cooling stack by a variety of methods, including asbestos concrete pipes and spray nozzles of brass or bronze, or through timber troughs with splash cups. In cold weather the droplets in the outer periphery of the tower tend to freeze giving an icicle build up on the packing which can obstruct air flow. To overcome this problem a de-icing ring is fitted to each tower. A considerable quantity of warm de-icing water may be required in really cold weather for this process.

Evaporative loss from a cooling tower is made up by abstraction from the river, which also provides any additional water which might be necessary to compensate for the purge from the cooling water circuit back to the river. The purge water discharged from the system is used to control the concentration of dissolved solids in the cooling water. Generally evaporation is 1% of the cooling water flow and the purge approximately a further 2%. Additional make up water will also be required for drift loss from the eliminators and any leakage in the system. Purge water is normally drawn off from the cooling tower system at the lowest temperature in the system so that it is returned to the river with the minimum increase above ambient temperature.

The hyperbolic shape associated with natural draught cooling towers has been under continual development since it was first introduced in about 1916. Its shape assists in improving efficiency, and reducing the surface area of the shell (compared with a cylinder of same diameter). It also has great natural strength and assists in saving of construction materials. The shape of the tower is also more resistant to wind stress.

The air flow is provided by the natural draught of the warm air and vapour in the shell. The packing assists in

preserving the structural integrity but has to be a compromise between presenting a large surface area and a low resistance to the air stream. Cooling tower performance is adversely affected by an increase in the temperature and humidity of the air. Design air conditions are generally taken as those experienced during late autumn/early spring. To assist in achieving maximum efficiency the water is distributed uniformly over the packing by sprays arranged along manifolds cordwise from a diametrically situated culvert. Uniform distribution is sometimes difficult to achieve in practice.

The eliminators above the cooling pack (Fig.1) are used to reduce water droplets being emitted from the top of the tower. Various forms of eliminators have been in use for over 35 years following a comprehensive investigation of the factors affecting droplet collection efficiency in a practical system by the electricity supply industry. (1) The eliminators have to catch both spray drops and the droplets formed during the passage of the water down the heat exchange packing which are sufficiently small to be re-entrained and carried upwards.

In the UK, water cooling towers are now usually specified and designed to British Standard 4485 Water Cooling Towers. It appears to be common practice to determine the thermal performance of cooling towers but it is difficult to obtain data on practical tests on the efficiency of the drift eliminators, although various estimates have been made. It appears that determination of even drift/or nuisance as defined in BS 4485, Part 2 "water loss from top of tower as liquid droplets entrained in the outlet air" is rarely carried out these days. (Ref. Appendix B, BS4485, Part 2). The environmental significance of the efficiency of the drift eliminators will be discussed further.

VISUAL IMPACT

The physical bulk of large cooling towers dominates most large power station sites particularly in flat countryside and they are considered to be visually objectionable by many people living in close proximity to the station. However, it is a situation they ultimately have to tolerate. The natural draught tower as used in the UK has generally been restricted in size, mainly on structural grounds, resulting in as many as 8 towers being required for a 2,000 MW station and 12 for the 4,000 MW Drax Station. The electrical utilities sought to minimise the visual impact of the cooling tower by using modern architectural planning techniques including using a variety of textures and colours for the towers. Notwithstanding all the ameliorant techniques adopted, the sheer massive physical bulk of large towers remains visually objectionable on some sites. The CEGB also sought to reduce

the visual impact of cooling towers by the development of an assisted draught cooling tower. In this type of tower the main shell is retained and the cooling efficiency increased by the use of electrically driven fans located at the base of the tower (Fig. 2), which supplements the natural draught up the tower while significantly increasing the cooling capacity. It was initially hoped that two of the fan assisted towers could replace eight normal draught towers. It was recognised that there would not be any significant saving in capital costs with a fan assisted tower and there would also be a significant increase in operational costs. A fan assisted cooling tower has been in operation at Ince B (Cheshire) power station for several years, but apparently the final evaluation results have not been reported in the Technical Press. Fan assisted towers were not adopted for Drax Power Station.

The visibility of the plume of water vapour and droplets from the top of the cooling tower is also sometimes a cause of visual amenity complaints as distinct from loss of sunlight. The length of the plume is determined by meteorological factors, high humidity conditions giving the worst plume effects. A 120 MW prototype "dry" cooling tower has been investigated at Rugeley Power Station (Staffordshire). In this system all the heat from the cooling water is dissipated by warming the air flowing up the tower, the warm water flows through radiator tubes at the base of the tower, and there is no evaporation or plume. However, there are a number of disadvantages with dry towers including increased size, corrosion of the radiator tubes and increased cost.

It is unlikely that any significant increase in costs for the design, construction and operation of cooling towers, or changes in cooling systems, would be considered justifiable by the new electrical utilities in terms of visual amenity alone. (2) (3).

THERMAL POLLUTION OF LOCAL RIVERS

There is still some concern about the possible adverse affects of discharging significant quantities of water from cooling tower re-circulation systems heated some 8-14^{o} centigrade above the ambient temperature of the river water. The CEGB has undertaken many ecological surveys investigating the effects of thermal discharge from power station sites covering both coastal and fresh water cooling systems. The overriding conclusion of these studies appears to be that, in general, there is no adverse or significant effect on the local life forms in rivers associated with the heat in a power station discharge. There continues to be some doubt about possible harmful effects, specifically in the area extending a few tens of metres around the actual point of the discharge.

The main reason for the absence of detrimental effects is that the warm discharge effluent rises to the surface of the receiving waters and floats there in a thin layer. The rise of warm water to the surface protects organisms living at mid depth and on the river bed against any adverse effects and also maximises the rate of heat dissipation to the atmosphere. With tower cooling the efficient aeration of the water can also be beneficial through the effluent discharge back to the river, which is frequently more oxygenated than the abstraction water. A large tower cooled station may add as much as 2 to 4 tonnes of oxygen to the river each day. However, some Water Authority representatives have suggested that it was the higher temperature in the Trent (with a relatively high density of power stations to the mile on the river) that was the main environmental factor inhibiting the restoration of the migratory salmon run. Other "experts" don't agree. (4) (5).

LOSS OF SUNLIGHT

There have been numerous comments and complaints from residents living close to some of the modern large power stations in the United Kingdom, alleging loss of sunlight and adverse local climate effects due to the emission of water vapour and droplets from cooling towers. Similar comments have been made for cooling towers at locations abroad.

With the completion of Drax Power Station 4,000 MW, with 12 cooling towers, there have been further complaints alleging that the operation of the increased number of cooling towers (there were 6 for Drax 2,000 MW) is now causing a significant loss of sunlight on occasions in the area, and in some instances affecting crop yield. Add the loss of sunlight from the Drax cooling tower cloud to the further loss due to the inline effect, which sometimes occurs from the other two large power stations in the Aire Valley (Eggborough 8 towers and Ferrybridge 8 towers) and one can readily appreciate the significant loss of sunlight which can occur, mainly at a time of year when sunlight is at a premium. Even on the days with total cloud cover and very high humidity, the additional cooling tower plumes usually layer just underneath the main cloud cover and significantly reduce the natural daylight in certain villages. On days such as these it is quite common for the humidity to be raised by the cooling tower plumes to saturation point and droplet fallout (drizzle) can occur for up to six miles downwind of the power station. On certain days in the autumn, winter and early spring, it is estimated that the inline effect of the Aire Valley Power Station cooling tower plumes reduces direct sunlight and/or the intensity of the daylight by as much as 1.5 to 2 hours in the course of a day. Because of the unique situation at Drax, 12

towers, and in addition the "inline" effect of the Aire Valley Power Station Cooling Towers, Selby District Council has repeatedly requested the CEGB and National Power to respond to the concerns of the local people and monitor the loss of sunlight, but this has been to no avail to date.

Drax was designed in the early 1960s as a 4,000 MW station, but was built initially as a 2,000 MW with a gap of approximately 16 years between initial design and when work started on its completion stage. Unfortunately, very little new water cooling technology was incorporated in the second stage of the development of the system and consequently it could be costly to reduce this nuisance and intrusion. Selby District Council would have liked consideration to have been given to the use of forced draught towers or other alternative cooling systems in the second stage at Drax to reduce the six new towers to one or two. (Fig.2).

In the United Kingdom the CEGB examined the local weather records for six weather stations located at distances 4 to 20 kilometres around a power station, with data from a further four sites along the direction of the prevailing wind extending to 112 kilometres from the station. The data examined before and after commissioning of the station was for total rainfall, hours of bright sunshine, and incidents of morning fog. It was concluded, by the CEGB, that the emissions from the station cooling towers did not have any significant effect on the parameters examined.

However, there now appears to be a reasonable case for a comprehensive investigation of the effects of 12 cooling towers on the local climate and with measurements made closer to the source at Drax. The possibility of improving the performance of the droplet eliminators in the towers at Drax and other sites should also be examined. If this could be achieved it would be environmentally advantageous in several respects. (6) (7) (8) (9) (10).

INCREASED NOISE FROM COOLING TOWERS

In the Selby area noise from natural draught cooling towers at the power stations does not appear to present a problem to local communities. In the case of natural draught cooling towers, noise is generated mostly in the drip area where the cooling water hits the surface of the water in the collecting pond, at the base of the tower. As a rule the frequencies determining the noise level are above 500 hertz. In general the total sound pressure level is approximately 6575 dB(A) at 50m from the tower. On some locations those noise levels may be considered a nuisance.

Acoustic specialists in Germany (11) have been working for more than ten years in the field of silencers for large cooling towers and already 35 cooling towers in West Germany and the Netherlands have been silenced by means of acoustic walls or splitter silencers around the collecting pond at the base of the tower. These noise protection measures reduce noise levels by 12 dB in the case of acoustic walls and 30 dB when silencers are used. The splitter silencers are made of salt water resistant aluminium to a height of 12 metres. (Fig.3).

SPRAY DRIFT FROM THE BASE OF COOLING TOWERS

Another potential environmental problem with cooling towers is that in strong windy conditions the wind blowing past the tower causes reduced pressure at the sides. This can result in water spray, sometimes being entrained in the tower wake and elevated to a height of 30m, carrying some distance downwind causing a local nuisance. If a public road is very close to the cooling towers as at Eggborough Power Station (Selby District) the blow out can cause inconvenience to pedestrians and cyclists, and these problems are aggravated by freezing conditions in winter. In some cases, as with Eggborough, it was necessary for the CEGB to install under road heating to reduce the worst effects in winter conditions. There is no easy solution to this problem, but surprisingly few complaints are received regarding this blow out. There is also the possibility of a potential health hazard with the blow out of contaminated river water droplets from the base of cooling towers. This will be discussed later (12).

EMISSION OF AEROSOL DROPLETS FROM THE TOP OF LARGE NATURAL DRAUGHT COOLING TOWERS

The emission of aerosol water droplets from the top of large natural draught cooling towers may contribute to the following environmental problems:-

a) Loss of visual amenity and sunlight, possible adverse effects on crop growth.

b) Drizzle from top of tower aggravating freezing road conditions, sometimes supplementing spray drift from the base of cooling tower.

c) Heavy deposition of tower droplets containing both dissolved and suspended solids can cause a nuisance, possibly commercial loss, when deposited on garden and field crops, cars, greenhouses etc.

d) Micro organisms in droplets could act as a potential

health hazard to people living in the vicinity in specific circumstances. (a) and (b) have been discussed previously.

Measurements of droplet fallout from cooling towers have been reported previously by the CEGB (1) (13). Water droplets falling from cooling towers were collected on water sensitive paper at various distances varying from 200m to 5km around several power stations. The rate of drizzle and the droplet size distribution were also determined. As expected the peak rate of drizzle was very sensitive to atmospheric humidity. Below approximately 60% relative humidity it appeared the drops evaporated and they were not detected on the ground. The distance to peak deposition area was commonly 200 to 600m with droplet sizes 80 to 500 microns in diameter. Nearer the source the droplet size tended to increase up to 600 microns and decrease further away, median 100 to 150 microns at 2km or more. The data was for specific operations and meteorological conditions and different results could be obtained in different circumstances. The quantity of drizzle from one station, Ratcliffe (Notts), was substantially improved following modification to substandard eliminators. More recent work (14) has identified difficulties and errors associated with monitoring cooling tower drift, particularly the smaller diameter droplets which may be more important in terms of their potential impact on humans.

In the Electricity Supply Industry and the UK in general, large natural draught cooling towers are built to standards generally consistent with B.S.4485, Water Cooling Towers.

National Power have indicated that in general the efficiency of eliminators in modern large cooling towers is in the range 92/98% i.e. the capture efficiency of droplets as determined by rig tests. (Efficiency is defined as the percentage of the mass of water droplets approaching the eliminator ie captured and returned to the tower pack). The water droplets represent a very small fraction of the circulating water through a tower. It is estimated by National Power that the amount of water leaving the eliminator as droplets is of the order of 0.02% or less of the cooling water flow for an eliminator in good condition (15). However, there is no droplet particle size data associated with National Power efficiency figures.

More recent work at the Public Health Laboratory Service Centre for Applied Microbiology & Research (PHLS-CAMR) Porton Down indicates that currently quoted efficiency of eliminators are generally for droplet particle sizes >50 microns, but for droplet size, for example, <10 microns the efficiency is substantially reduced. (17). The air speed in a N.D. Tower

is between 1.5 - 2.5 m/sec.

However, the total evaporation from a large cooling tower water system would be approximately 1% of the total circulating water which would be approximately 1.5 m^3/sec (1.2 x 10^6 gallons/hour,
or 28.8 x 10^6 galls/day) for Drax Power Station, with all the cooling towers on full load. (16).

It has recently been established that HM Inspectorate of Pollution (HMIP) are responsible for the quantity of drift droplets from large cooling towers i.e. ensuring the efficiency of eliminators, and the Health and Safety Executive is responsible for the quality of water emitted from the cooling towers ie for ensuring the water droplets emitted are not harmful in any way to the general public in the area. Selby District Council is awaiting written confirmation of the responsibilities of the Health and Safety Executive in this matter.

Apparently, many of the larger cooling tower systems are operating on river waters which have been polluted with significant quantities of untreated or partially treated sewage effluent. In addition many of these river waters may be polluted with a wide range of industrial effluents and agrochemicals. Our experience at Drax and elsewhere indicates that the comprehensive composition and concentration of bacteriological/viral/chemical pollutants in the river waters used in large cooling towers is generally not known by industrial users, or even by the regulatory authorities. Apart from some research test results for Legionellae, there is specifically very little, if any, data on the bacteriological/viral quality of cooling waters used in large draught cooling towers. Similarly, there appears to be very little data available on the quantity/quality/size range of river water aerosol droplets emitted as drift from large cooling towers. Some cooling towers appear to have been commissioned without even initially ensuring that they comply with the drift loss requirements of British Standard 4485, Water Cooling Towers. The normally accepted requirement for nuisance precipitation rate is defined as not exceeding 0.025mm/h as defined in Table 4 of B.S.4485, Part 2, 1988.

It has also been established that the water in large natural draught cooling towers sometimes contains _Legionella pneumophila_ organisms (18) (19). The number of organisms are usually relatively low but comparatively high concentration levels have occasionally been found in some systems (20) including Drax (Table 1). The factors controlling the

development of large numbers of Legionellae in cooling waters are not fully understood. The former C.E.G.B. (National Power/Power Gen) initiated several comprehensive studies of the growth of Legionellae in cooling water systems, but, unfortunately, the results have not been fully published. It is understood the C.E.G.B./National Power investigations did not include measurements for any micro organisms emitted with droplets from the top of cooling towers.

As far as Selby DC is aware the only measurements for micro-organisms in large cooling tower drift droplets in the UK were carried out by Professor Lacey (Leeds University), of his own volition, around Drax PS. Professor Lacey took air samples at distances of 1/8 to 6 miles from Drax on 10 days in August/September 1986. The samples were examined for Legionellae organisms and all gave negative results (there were no tests for other micro-organisms). Professor Lacey emphasises the test series was very limited and his results are valid only for the specific operational and meteorological conditions pertaining for the test period. In recent discussions Professor Lacey confirmed his view that, in general, in normal conditions, there is probably no problem with the emission of Legionellae from large cooling towers. However, he stated there is still a need for further research work to investigate the possible carry over of organisms under adverse meteorological conditions and with heavily polluted river waters (25).

[Addendum 11.10.90 (following the comments of Professor Lacey)

This last week I received translations of research work published in Germany in 1979 entitled "Microbial Emission, Immissions and Changes in Germ Count in the Cooling Water during the operation of Water Cooling Towers", E. Baer et al 1979.

It referred to a specific German river and power station. This work did not include any tests for Legionella organisms.

It was concluded that:-

(a) Micro-organisms can be emitted in the droplet/plumes from large cooling towers.

(b) There was no signficant depostion of, or increase in air concentration of, pathogenic micro-organisms at ground level. (UK micro biologists have queried the accuracy of some of the sampling procedures adopted for these surveys).

(c) The cultivation of fruit/vegetables should be prevented in the immediate vicinity of large cooling towers (150m).

(d) It is of primary importance to have knowledge of the pollution levels of the cooling waters.

(e) Where a risk exists, a reduction of risk must be achieved through modifications or use of chemical additives to the circulating water.

Some of the results are reassuring, other results confirm SDC's view that test work is required on some of the large UK tower cooling systems.

It is unfortunate that a similar programme of work on cooling tower systems was not undertaken by the CEGB in risk areas in recent years.]

The CEGB and successor companies have stated that no large power station updraught cooling tower has been implicated as a source of an outbreak of Legionaires' disease. However, it is understood there have been a number of cases of Condenser Cleaners Disease and Pontiac Fever, that were associated with power station cooling water, over the years before legionellosis was identified and named as such in 1976. In addition, there have been at least three instances in the USA in which workers contracted legionellosis after cleaning power station cooling systems (21). Recent work also in the USA indicates that the dissemination of viable legionellae may occur over larger distances eg up to 2 miles, (3.2 kilometres) than was previously recognised. (22).

The cooling water is chlorinated in most large power station cooling systems, but usually only at a level to reduce biofouling of the condenser tubing. Regular chlorination at 1-2 ppm is recommended as the most consistent and effective treatment for legionella. (23). In addition a DHSS Advisory Committee on Biocide has issued a Report (26) on the use of Biocides in the control of legionellae in cooling tower water systems. The Health and Safety Executive (HSE) have also issued a consultative document. The Control of Legionellosis, Proposals for Statutory Action C.D.18 (F), 11/89 which proposes a range of possible actions which might help to reduce the incidence of legionellosis generally.

There appears to be very little data, particularly from the United Kingdom, on any measurements to determine if legionellae and other microorganisms (including enteroviruses) are emitted in a viable form in the droplets from large

natural draught cooling towers; particularly when the towers are using severely polluted river water in adverse meteorological conditions, possibly presenting a potential health hazard to local residents.

COOLING TOWER EMISSION INCIDENT AT DRAX 4000 MW STATION IN SEPTEMBER/OCTOBER 1989

On Sunday 1 October 1989, Selby District Council Environmental Health Department Officers received a number of complaints from residents in Drax village concerning the fallout of water droplets, which evaporated to leave a widespread and severe dust deposition in the village.

Results and observations from initial investigations by Selby Environmental Health Officers on 1 October 1989

a) The water droplets appeared to be falling from cooling tower plumes from the local Drax Power Station. The cooling tower plumes were ultimately descending to a relatively low level in the village area. The water droplets had been deposited over a wide area in the village covering cars, (Fig.4) garden crops, greenhouses, and windowsills etc.

The water droplets, on evaporation, deposited a fine brown powde. These droplets were collected on a sheet of white A4 paper and increased in concentration closer to the station cooling towers. Although it appeared that the dirty droplets, (brown in colour) were emitted by all 12 towers, the worst effect appeared to be occurring closer to the six towers at the north end of the station. The north end cooling tower group is approximately 1 mile from Drax village and the southern tower group about 3/4 miles from the village.

b) A preliminary microscopic analysis of the deposit, later in the day, indicated the deposit did not contain any P F Ash cenospheres (normally characteristic of deposition from power station chimneys) but consisted almost entirely of small irregular shaped particles of what appeared to be clay/quartz, characteristic of river silt.

c) In the Selby area, on the 1 October it was overcast,

with rain between 0900/1000 hrs, an inversion at 3000 ft throughout the day, surface wind at 280°, with a speed 4 miles per hour (Leeds Weather Centre Data). In the village it was misty with intermittent light drizzle throughout most of the day.

d) A check test with A4 paper indicated that there was no fallout of deposit upwind of the station, indicating the Drax cooling towers as the source of the problem.

e) Numerous complaints were made to the power station control room by both angry residents from the village and Selby District Council officers. Unfortunately, representatives from the power station did not visit the complainants or inspect the effects of the heavy fall of droplets on the day. Also, unfortunately, HM Inspectorate of Pollution, who are the statutory regulatory authority, for emissions from both the station chimney stack and cooling towers were not available to take complaints over the weekend period.

f) Residents in the village were attempting to clean up the heavy silt deposit from cars, greenhouses etc, but in many cases the surfaces were fouling as quickly as they were cleaned. Some of the village residents were aware that the local river water used by the power station for cooling was contaminated with untreated sewage effluent from the local works. They expressed concern about potential health hazards with water droplets from the cooling towers. Some young children were also working in the mist/drizzle assisting their parents to clean cars.

g) A sample of the <u>dried</u> silt deposit taken from a car on the 1 October was subsequently examined by the Public Health Laboratory Services, Leeds and found to contain small numbers of <u>Legionella feelei</u> and <u>Escherichia coli</u> organisms. Table 3.

Further results and observations on the cooling tower emission incident at Drax power station in October 1989 established after the initial complaint on 1 October.

a) The emission of silt from the cooling towers continued for a further <u>8 days</u> before National Power stated they had found a damaged droplet eliminator in No 4a cooling tower and removed the tower from service. Throughout the <u>8 day</u> period the station generally continued on full load. It is the view of Selby District Council and their advisors that the faulty eliminator could and

should have been identified and taken out of service on the first day of complaints. There is ready door access to the interior of each tower above the eliminator. With precautions the towers can be inspected whilst on load. Neither HMIP nor the Health and Safety Executive required National Power to even reduce load during the 8 day period when the contaminated droplets and silt were still being deposited on local villages. Subsequently, National Power stated that they broke all production records for Drax during 1989/90!

After the incident HMIP informed Selby District Council Environmental Health Committee that there was very little HMIP could do if the incident occurred again.

b) In view of the unacceptable attitude of the regulatory authorities towards the Drax Cooling Tower Emission Incident Selby District Council served a prohibition notice under the Public Health (Recurring Nuisance) Act 1969. If there is a repeat of the nuisance the permission of the Secretary of State will be necessary to apply for a Court Order. The Council will also need to consider proceeding under Section 100 of the Public Health Act 1936 or preferably Section 222 of Local Government Act 1972.

c) Subsequently National Power confirmed that the suspended solids in the river water had increased substantially throughout the summer months due to the drought conditions, resulting in suspended solid concentrations of 40/60000 ppm on occasions in the make up water. The station's cooling water sedimentation, and treatment plant was inadequate for containing these high levels of suspended solids. Heavy deposition of contaminated silt occurred throughout the cooling system and the station's environs. Ultimately, the plastic droplet eliminator, which was on trial in No 4a cooling tower, collapsed with the weight of solids, allowing substantial quantities of contaminated river water and silt to pass through the tower and be deposited on local villages.

d) The chlorination plant on the station was unable to maintain free chlorine in the cooling water system due to the very high concentration of suspended solids in the water. Indeed it is not designed to do so.

e) HMIP Confirmed that there was no test data available for the efficiency of the eliminators on the cooling towers at Drax Power Station.

f) No significant cases of illness that could be clearly associated with this incident were reported to local medical practitioners. However, Selby District Council Officers did advise village residents on the 1.10.09 that it would be prudent to avoid working in the area of the droplet fallout.

g) L.pneumophila had been found previously in the Drax cooling water system, some of the results had been published by Leeds University (20). However, National Power adamantly refused, despite several requests, to release the CEGB Legionella Survey Reports for the Drax cooling system, (the surveys had been carried out over several years) to Selby Medical and Environmental Health Officers investigating the complaints. The secrecy on the part of National Power created suspicion and aggravated the concern of village residents exposed to the contaminated silt. For some reason National Power was afraid Selby District Council officers would publish the results if they were made available to the local authority. Simultaneously, National Power would not even publish their version of the Drax legionella survey results.

h) There was no data available on the other micro organisms (other than legionellae) which could have been present in the contaminated river water droplets eg enteroviruses. Recent analysis of samples on the River Ouse taken by Selby DC Officers close to the intake position for Drax cooling water are given in Table 2 (which also includes some results for the River Aire, which serves Eggborough & Ferrybridge Power Stations). The results indicate that cooling water at the intake position does contain levels of micro organisms on specific days, which our consultant microbiologists consider could be a potential health hazard if emitted from cooling towers as viable organisms in certain conditions. Fig. 5 indicates number of occasions when the Meteorological Office predicted areas around Drax PS may be exposed to low level cooling tower plumes between April and July 1990. Table 3 presents analysis of samples from the Drax Cooling System on 13 October 1989 after the incident.

i) A consultant microbiologist from the Public Health Laboratory Service (24) advised Selby District Council that a comprehensive independent investigation would be required to determine if there was any potential health hazard to local residents associated with the possible

emission of micro organisms in power station cooling towers, when operating with highly polluted river water in adverse metereological conditions. The adverse meteorological conditions include inversion under 3000 ft., wind speed 2-10 mph, relative humidity >85% (Meteorological Office).

j) National Power maintained throughout the incident and subsequent investigation that there was no health hazard to residents exposed to the contaminated aerosol droplets/silt in the villages. Selby District Council, advised by various consultants, are of the opinion that National Power did not have the data specific to the time of incident i.e. bacteriological and viral analysis of aerosol droplets or quantity and particle size of droplets falling on residents, to state categorically "that there was no health hazard to local residents."

k) National Power have consistently said, throughout the incident, that emissions from power station chimneys or cooling towers or subsequent complaints arising, were not the concern of local authority officers and that a power station is a registered works and subject only to HMIP requirements. Whilst accepting that HMIP are the regulatory authority for Power Stations, Selby District Council does not agree with, or accept, National Power's narrow and legally incorrect view of local authority responsibilities. National Power's attitude towards the local authority's role in investigating environmental complaints against power stations causes concern for future relationships.

l) Subsequent to the incident and following strong complaints from the local MP, Council and residents, National Power have undertaken comprehensive investigations to improve the performance of the cooling water sedimentation and treatment system. Modifications to the plant and changes in procedure include :-

i) Better control of river water intake i.e. abstraction at low silt levels where possible.
ii) Improved prevention of silt build up in the system.
iii) Plastic eliminators replaced in cooling towers. All remaining eliminators cleaned.
iv) Regular pond cleaning programme has been instituted.
v) Temporary flocculation plant installed with a possibility of permanent plant later in

the year.

vi) A silt alarm system linked to the control room has been installed.

vii) Modification to sedimentation tank outlet has been completed.

Overall, National Power claims silt levels within the CW system have been maintained at 50/100 ppm in recent months, even though suspended solids concentrations have reached 70,000 ppm in the extracted river water. There have been no further complaints since the above measures were taken. However, it is still not known if pathogenic micro organisms are emitted in the drift droplets from the cooling towers, and possibly presenting a health hazard to local residents in adverse meteorological conditions.

CONCLUSIONS

The major unresolved environmental problems associated with large natural draught cooling towers in the U.K. would include the following, but are not exclusive of others.

a) Drax 4000 MW is unique in the UK in having twelve large natural draught cooling towers on one site. There are complaints and observations which indicate the cooling tower plumes from Drax cause a significant loss of sunlight and some alleged loss of crop yields in specific areas. These adverse local effects appear to be aggravated by contributions of cooling tower plumes from other power stations (Eggborough and Ferrybridge 'C') which are "in line" with Drax on some occasions.

   The continuous complaints over several years indicate that it is necessary to investigate and quantify the alleged adverse climatic effects due to cooling tower plumes in the Drax area on specific occasions.

b) Subsequent to the Drax Cooling Tower Emission Incident, October 1989, Selby District Council concluded that there is a need for further action on cooling tower emissions, particularly in the Drax area, which probably has the highest concentration of large cooling towers in the smallest geographical area in the UK.

There is very little data on (a) bacteriological/viral/chemical composition or (b) the quantity/particle size of the cooling tower drift droplets from Drax and many other cooling tower sites, that are deposited in local villages in certain weather conditions.

This is particularly important in view of the highly polluted river water often used in these cooling systems, including Drax, which is significantly contaminated with untreated sewage effluent.

Following advice from the Medical Officer for Environmental Health, Consultant Microbiologists and encouragement and support from the Secretary of State for Health, Selby District Council has initiated an independent and comprehensive investigation into pathogenic micro organisms that could be emitted in the drift droplets from large natural draught cooling towers and deposited on local villages in adverse meteorological conditions in the Selby District. The investigation has been designed by a Consultant Microbiologist from PHLS - CAMR.

If necessary the studies will include a risk assessment of any potential health hazard for local residents associated with droplet emissions. It is anticipated that other appropriate local authorities, HMIP & HSE, National Power and Power Gen will participate in these investigations in an honest endeavour to ascertain the truth of the situation.

SELBY DISTRICT COUNCIL INITIAL RESEARCH PROGRAMME PROPOSALS

INVESTIGATION TO DETERMINE IF PATHOGENIC MICRO ORGANISMS ARE EMITTED IN THE DRIFT DROPLETS FROM POWER STATION COOLING TOWERS AND IF THEY PRESENT A HEALTH HAZARD TO LOCAL RESIDENTS.

It is intrinsic to cooling tower design and operation that some of the water in the cooling system, and anything suspended or dissolved in that water, is released from the tower during normal operation. This loss is termed "Drift". It is unknown if the drift from large natural up-draught cooling towers such as those at power stations, can return to ground while the pathogenic organisms within it, if any, are still viable and infective.

The aim of this project is to test the plume from large up-draught towers at points downwind from the towers for the presence of viable airborne organisms derived from the water in the towers.

Samples will be restricted initially to within 500 metres of the towers and to times when the plume is coming near to ground, or preferably, down to ground level. (Fig. 6).

Air samples will be collected with all glass cyclones using Page's amoebal saline (PAS) as the collecting fluid. The cyclone will operate at 500-1000 litres/minute.

It is proposed additional samples (5 litre) of the water flowing over the tower packs will be collected from the inlet culverts to the towers, providing the project can be agreed with National Power, who have already indicated their willingness to consider participating in this research work.

The survival of an organism in an aerosol is complicated and depends on a number of factors apart from the external environment. The state of the organism in the first place is important, also the fluid it has been suspended in. External environment factors include the effects of ultra violet radiation and the open air factor (OAF), believed to be due to the toxic effects of ozone olefins in the atmosphere. Microbiological parameters to be measured will include (a) Total viable bacterial counts in air (b) Total viable bacterial counts in water sample (c) legionella count (d) E.coli and coliform counts (e) enteroviruses and other micro organisms. (24).

REFERENCES

1. Chilton H. Elimination of Carryover from Packed Towers with Special Reference to Natural Draught Water Cooling Towers.Trans. Inst. Chem. Eng. - 30.4.52

   The performance of Natural Draught Water Cooling Towers.Proc. I.E.E. 99 (Pt II) 440 - 1952.

2. Clarke, A J et al. Electricity Supply and the Environment.Published by Central Electricity Generating Board 1980.

3. Barber, F R et al. Persistance of plumes from natural draught cooling tower. Atmos Environ, Vol. 8, No. 4, pp 407-18. 1974. (Presented at Symposium on Environmental Effects of Cooling Towers, CEGB, Leatherhead, Surrey, England. March 27-28 1973.

4. Langford, T E. Electricity Generation and the Ecology of Natural Waters. Liverpool University Press England 1983.

5. Clarke, A J et al. Power Generation and Environmental Protection. The Conservation of Water Resources. J. IWEM., 1988 - 2 August - pp 353-359

6. Martin, A. Influence of a power station on Climate. A Study of Local Weather Records. Atmos Environ, Vol.8 pp 419-424, 1974.

7. Patrinos, A.A.N. et al. Meteorological Effects of Heat and Moisture Release from large power stations. (Precipitation Modifications). Oakridge Laboratory Report No Conf. 780520-6 1978 (Meeting on thermal power plant heat rejection system. Yerovan. USSR Nov. 1978)

8. Laurmann, J. Modifications of Local Weather by Power Plant. EPRI REPORT. EPRI-EA-886-SR/TPS76-668. Aug. 1988.

9. Kramer, M. L.et al. Cooling Towers and the Environment Building Systems Design. Nov. 77, V.74, N6. P.27(5). Smith Singer Meteorologists NY.

10. British Standard 4485, Water Cooling Towers. Part 1, Glossary of Terms, Part 2, Methods for performance testing, Part 3, Code of Practice for thermal and function design, Part 4, Structural Design of Cooling Towers.

11. Winkler, A. (GERB Akustie Consult, West Germany - Personal Communication to N H Parkinson.

12. Gardner, B.R.et al. The Research & Development Background to the environmental problems of natural draught cooling towers.Atmos Environ, Vol. 8, No. 4, pp 313-20 ,1974.

13. Martin, A, et al. Measurements of precipitation downwind of cooling towers. Atmos Environ, Vol. 8, No. 4 pp 373-81 April 1974.

14. Golay, M.W. et al. Comparison of methods for determining cooling tower drift. Atmos Environ, Vol.20 , pp No 2, pp 269-281, 1986.

15. Marshall, Lord. Personal communication to Rt Hon Michael Alison MP.

16. Neal, G, (National Power, Drax PS) Personal communication to Selby D.C. Officers.

17. Lee, J.V. Personal communication to Selby DC

18. Bonnell, J.A. et al. Legionella in power station cooling water. Lancet. Aug. 10 1985. pp 327-322

19. Solomon, J.A. et al. Distribution of Legionella pneumophila in Power Plant Environment - p 309 . Legionella - Proceedings of 2nd International Symposium. American Society for Microbiology - Washington DC 1984.

20. Curley, P.K. Properties of legionella in power station water - University of Leeds, Department of Microbiology - June 1989, M.Phil thesis.

21. Tyndall, R.L. et al. Legionnaires' Disease Bacteria in Power Plant Cooling Systems - Downtime Report. EPRI Report EPRI-EA-4300, Final Report Nov. 1985.

22. Addis, D.G. et al. Community acquired Legionnaires' disease associated with a cooling tower. Evidence for larger distance transport of Legionella pneumophila. Amer Jour Epid Vol. 130, No 3 1989.

23. Legionnaires' Disease Guidance Note EH.48. Health & Safety Executive. Environmental Hygiene Series 48, Jan. 1987.

24. Lee J.V. Personal communication to Selby DC.

25. Lacey, R.W. Personal communication to Selby DC.

26. HMSO 1989. Report of the Expert Advisory Committee on Biocides, Department of Health.

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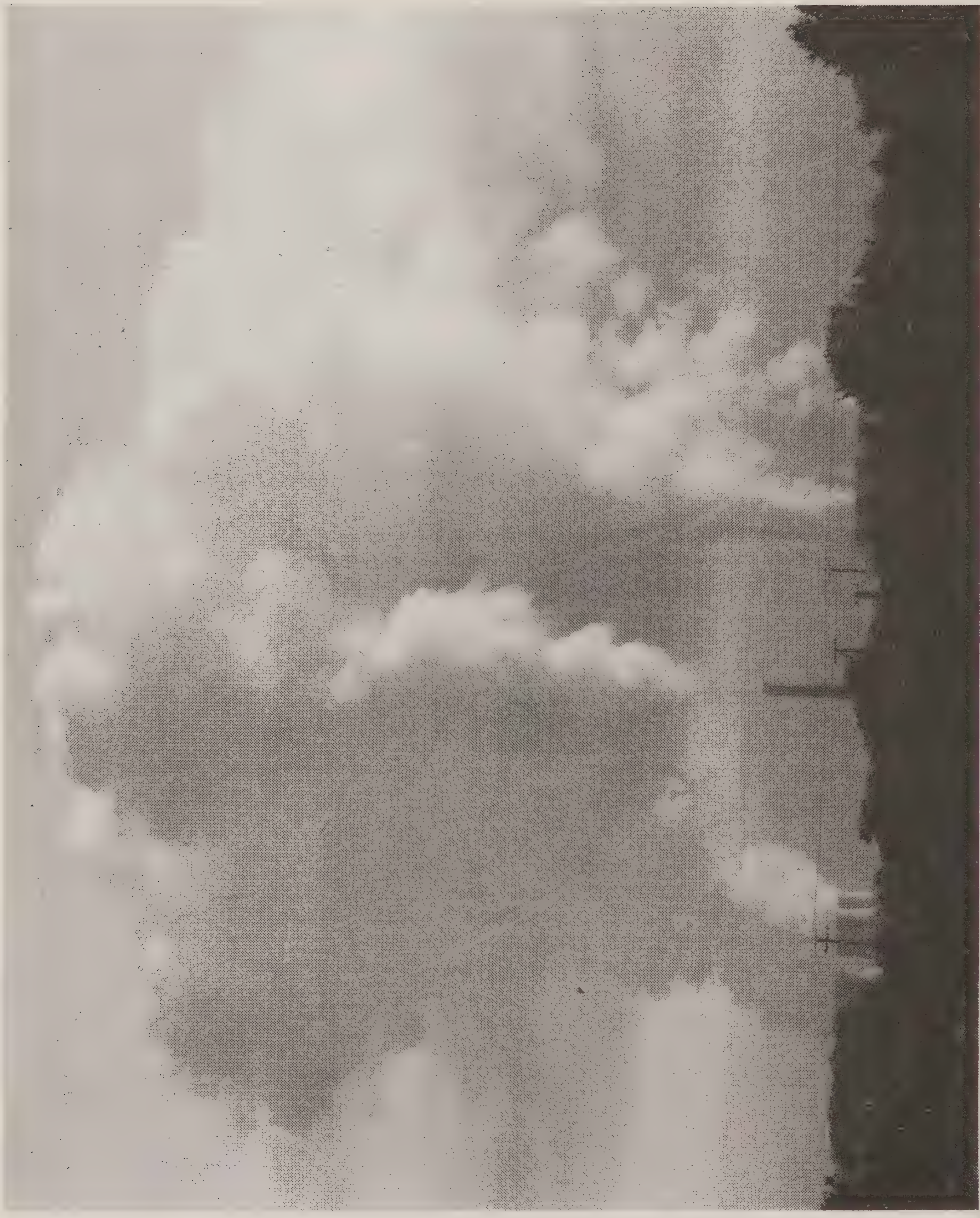


Plumes from Drax P.S. viewed six miles from the station.

TABLE 1

RANGE OF LEGIONELLA COUNTS PER LITRE FROM WATER SAMPLES AND COUNTS PER SWAB

(Colony forming units (cfu) of <u>Legionellae pneumophila</u> per litre of water or counts per swab.

cfu legionellae/l or swab	No of water samples with count in range	%	No of swab samples with count in range	%
100-999	32	17.2	3	11.1
1,000-9,999	43	23.1	6	22.2
10,000-99,999	74	39.7	9	33.3
100,000-999,999	32	17.2	6	22.2
>1,000,000	5	2.6	3	11.1
Total	186		27	

(Taken from Curley P M Properties of Legionella in Power Station Cooling Water, University of Leeds 1989. Department of Microbiology 1989).

NB In total 959 water samples from 80 different sites at Drax P.S. and 82 swabs from condensers were taken for examination as part of the above survey. 186 water samples (19.4%) and 26 swabs (31.7%) grew Legionella organisms as indicated above.

RESULTS FOR RIVER WATER SAMPLES TAKEN NEAR POWER STATION INTAKES - DRAX/EGGBOROUGH

DETERMINAND	UNIT	RIVER OUSE							RIVER AIRE	
		14-5-90		21-6-90		6-8-90		11.9.90	13-8-90	11-9-90
		14.30	16.00	13.30	16.00	12.00	12.45	9.50	15.15	12.00
Solids Particulates	Mg/L	1626	2268	3382	3576	5825	11765	940	10	64
E.coli	no/100mL	4500	15000	32000	40000	84000	105000	30000	3900	1700
Coliforms	no/100mL			100000	127000	322000	224000	106000	4000	227000
Enterovirus	PFU/10L	17.8	27.9	0	0	7.4	0	36.8	52.5	33.36
Cryptosporidium	no/L	0	0	0	0	0	0	0	0	0
Legionella	no/L	0	0	0	0	0	0	0	0	0
Salmonella	MPN/L	0	3	7	4	170	170	5	0	5
Pseud aeruginosa	CFU/mL	0	0	0	0	0	0	1.1	0.1	2
Aer. hydrophila	CFU/mL	280	430	410	310	200	220	300	80	330
Rotavirus	FF/10L	31.9	29.9	0	0	4.62	0	7.67	8.75	18.65
		Falling Tide	Low Tide	Falling Tide	Falling Tide	Falling Tide	Falling Tide	Tide Turning	Non-tidal	Non-tidal

NOTE: All results have a standard error of +/- 20%.

UNITS

mg/L = milligrams/litre
mL = millilitres
PFU = plaque forming units
L = litre
MPN = most probable number
CFU = colony forming units
FF = fluorescent focii

Analysis completed by Yorkshire Water Laboratory Services,
Yorkshire Water Enterprises Ltd.

L15AFN

Table 3

SELBY DISTRICT COUNCIL

SAMPLING RESULTS - DRAX POWER STATION - 13 OCTOBER 1989

LOCATION	COLIFORMS /100ml	E.COLI /100ml	WATER SEDIMENT CULTURES No OF COLONIES/0.1ml OF HEAT TREATED WATER (L.feelii) X10 = No/ml SUPERNATANT*		SEDIMENT IMMUNOFLUORESCENCE FOR LEG SP	
					L.pneumophila sgps 1-6	L.feeleii
Water Inlet C line	10,000+	10,000+	-	Supernatant	-	-
No 3 Storage Tank after weir	10,000+	10,000+	-	"	-	-
4A Cooling Tower Pond	4,600	180+	+(1)	" X	+/-	++
6A + 6B Cooling Tower Pond	10,000+	10,000+	+(2)	"	-	+
4B Cooling Tower Pond	10,000+	1,000+	+(8)	"	-	+/-
5B Cooling Tower Pond	10,000+	1,000+	+(1)	"	-	+
6B Condenser Outlet	10,000+	10,000+	+(1)	"	-	+
5B Condenser Outlet	10,000+	1,000+	+(3)	"	-	+
4B Condenser Outlet	10,000+	10,000+	-(c)	"	-	+
Dust-Dry Powder collected 1.10.89	<100/g	<100/g	-	Dry Powder	-	+/-
					- None Seen, +/- <5m + Scanty, ++ Moderate, +++ High Numbers Seen	

* All sediment plates overgrown by other bacteria, some mould colonies.
X Mainly water, little sediment in original sample.
C More competing bacteria isolated from this sample. Probably positive.

SUMMARY: Legionellae consistent with L.feeleii isolated or detected in all water and sediment samples except those from the water inlet line and No 3 storage tank after the weir. Amoebae isolated from all samples.

L12AGB

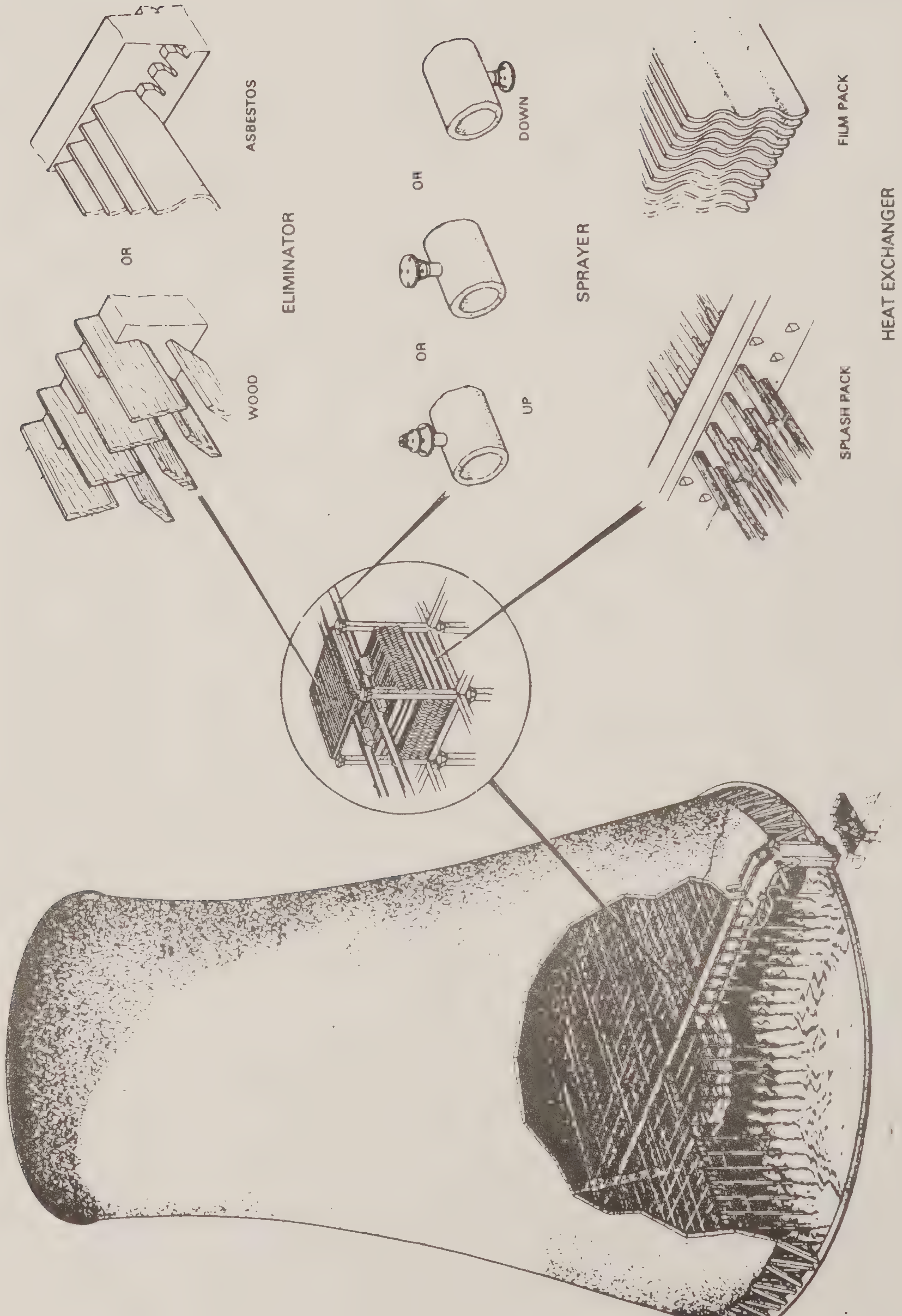


Fig. 1 Typical Natural Draught Cooling Tower

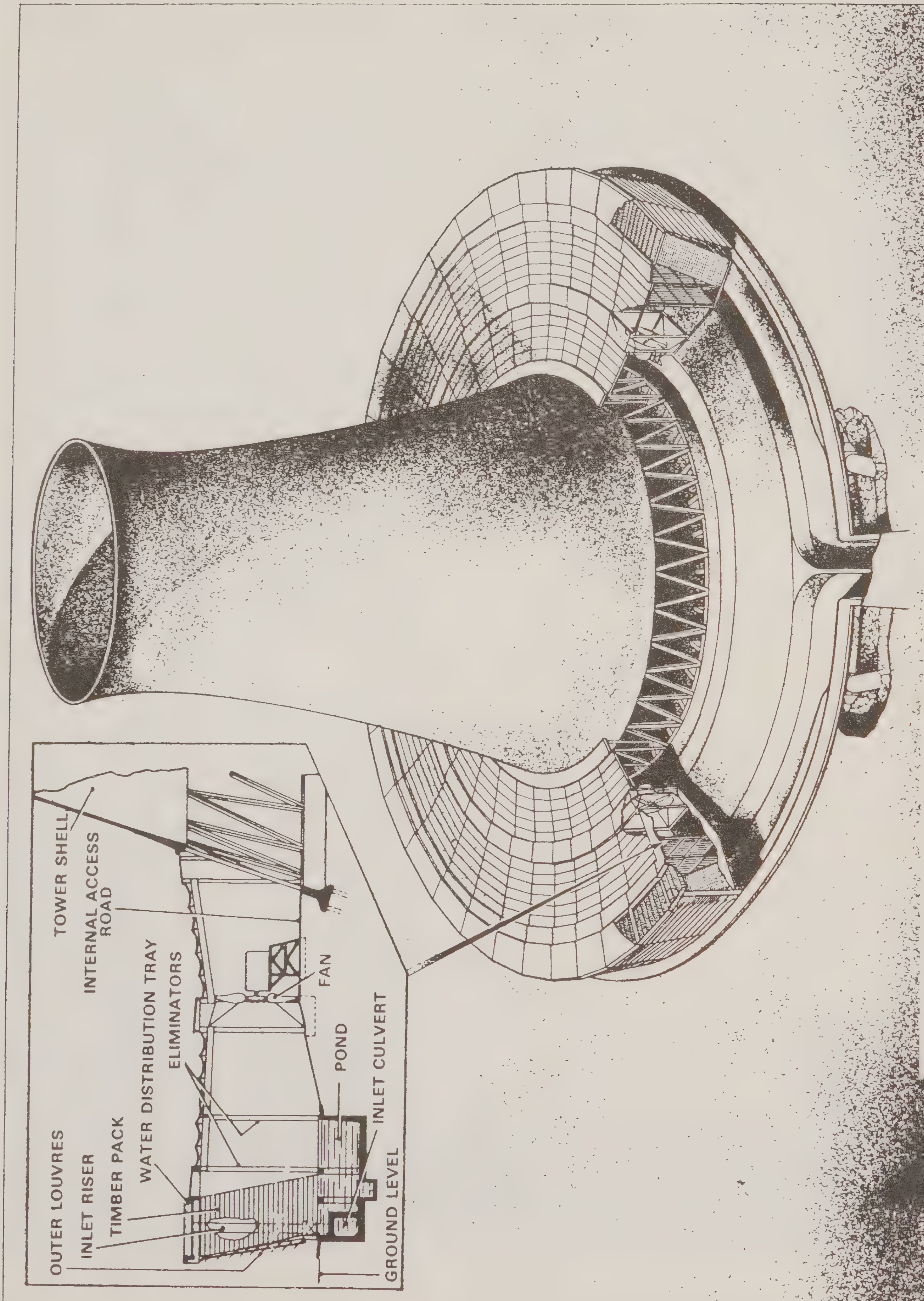


Fig. 2 Assisted Draught Cooling Tower

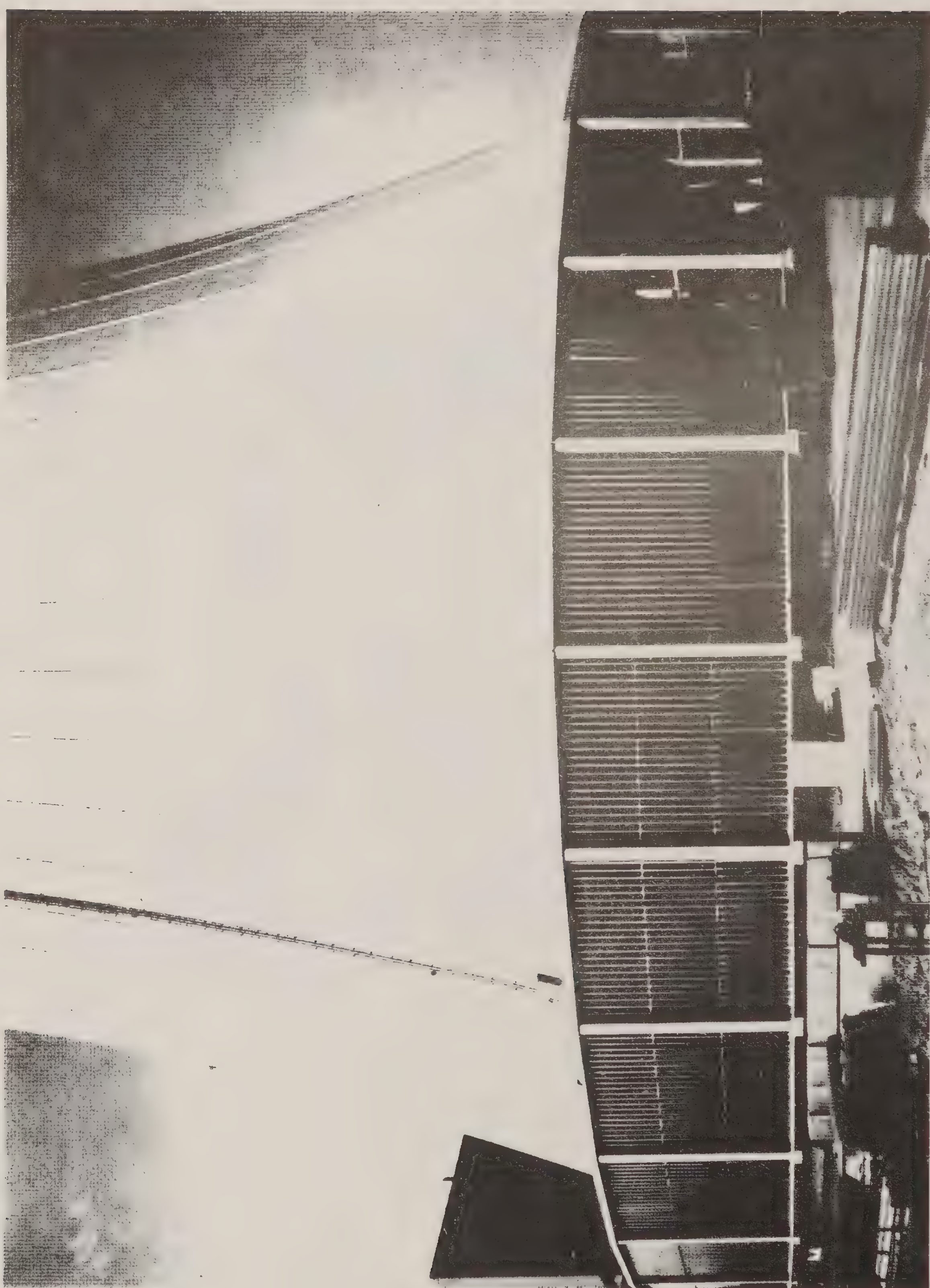


Fig. 3

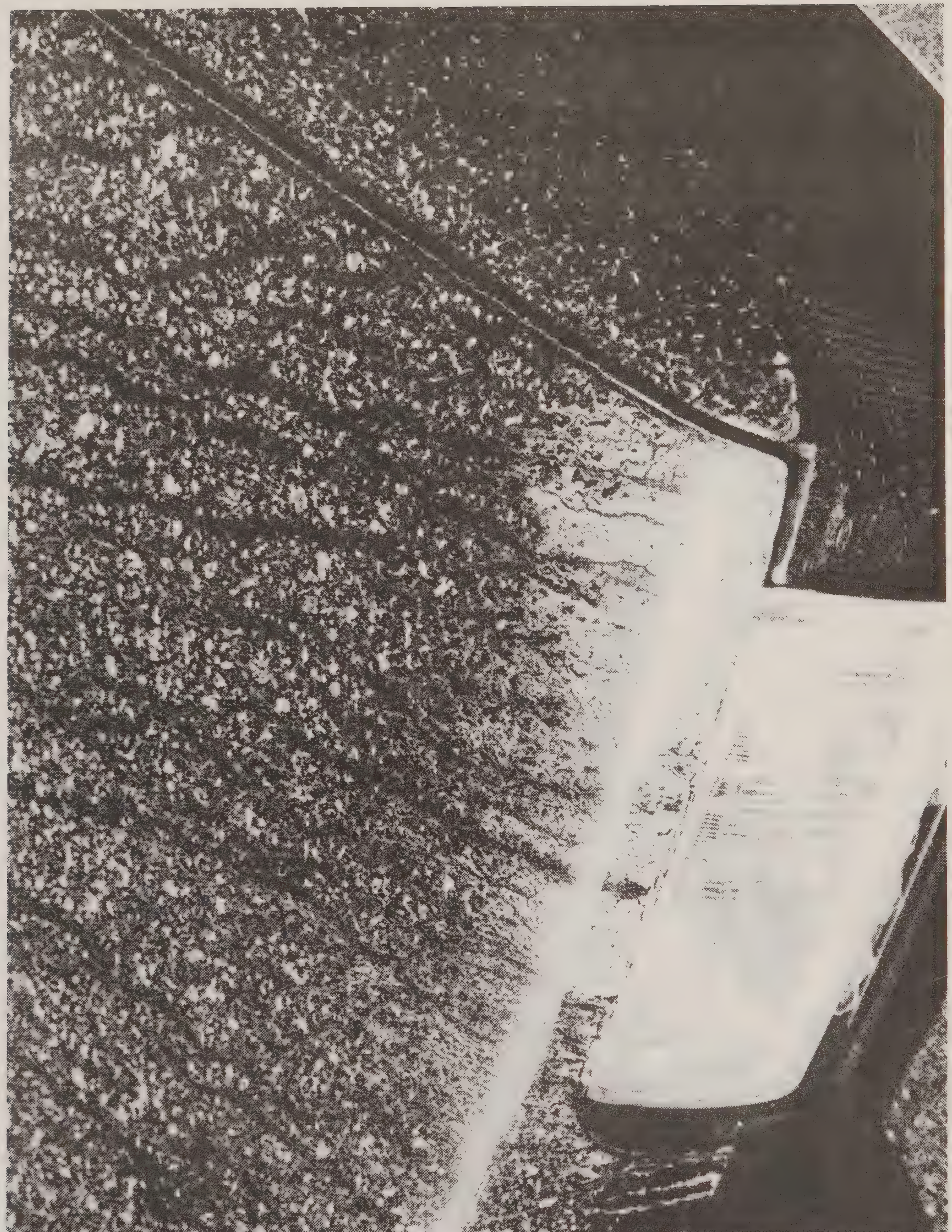
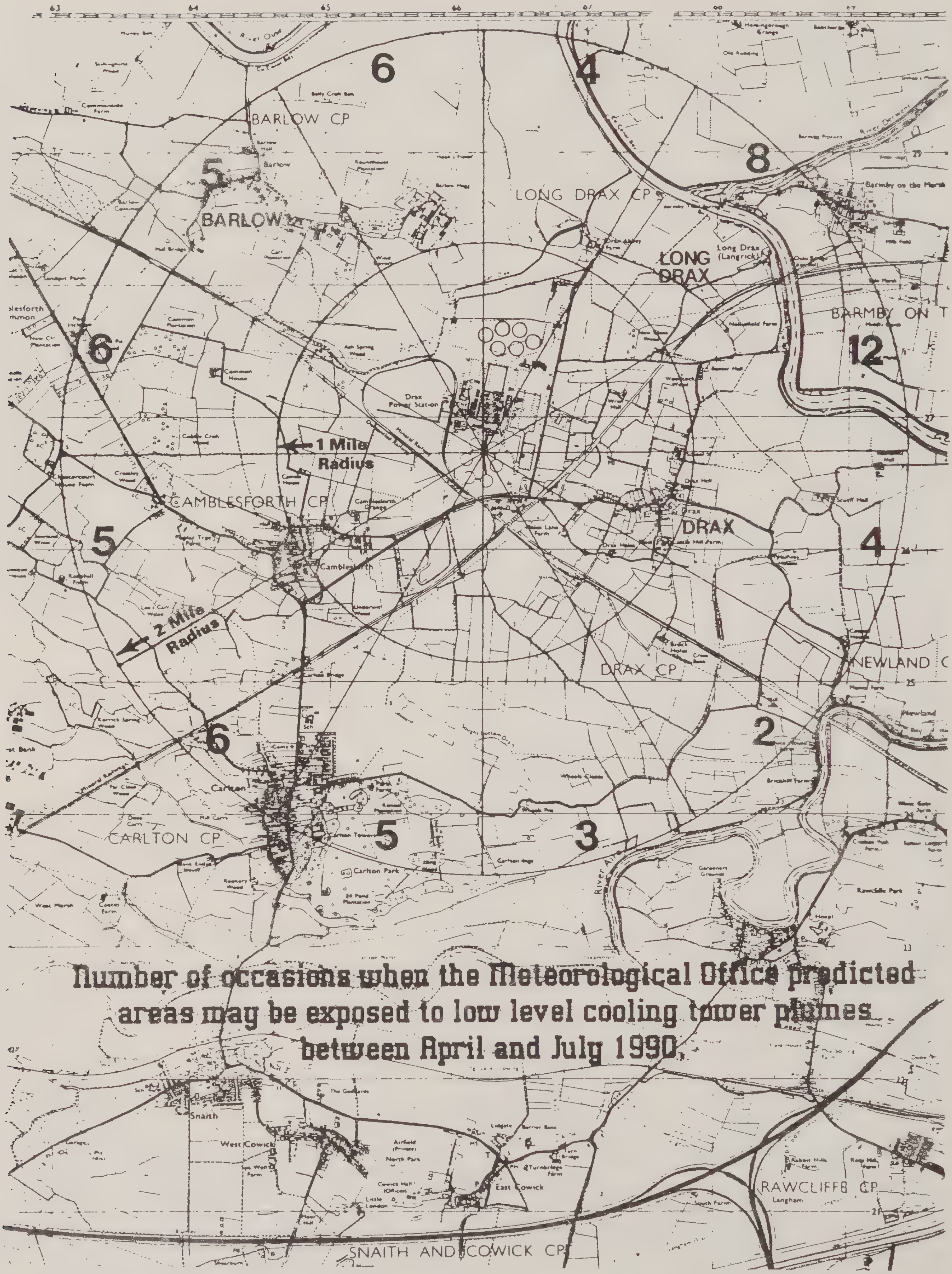


Fig. 4



BARLOW CP
BARLOW
LONG DRAX CP
LONG DRAX
BARMBY ON T
CAMBLESFORTH CP
DRAX
NEWLAND C
DRAX CP
CARLTON CP
RAWCLIFFE CP
SNAITH AND COWICK CP
1 Mile Radius
2 Mile Radius
Drax Power Station
6
4
8
5
6
12
5
4
6
2
5
3
Number of occasions when the Meteorological Office predicted areas may be exposed to low level cooling tower plumes between April and July 1990.

Fig. 5

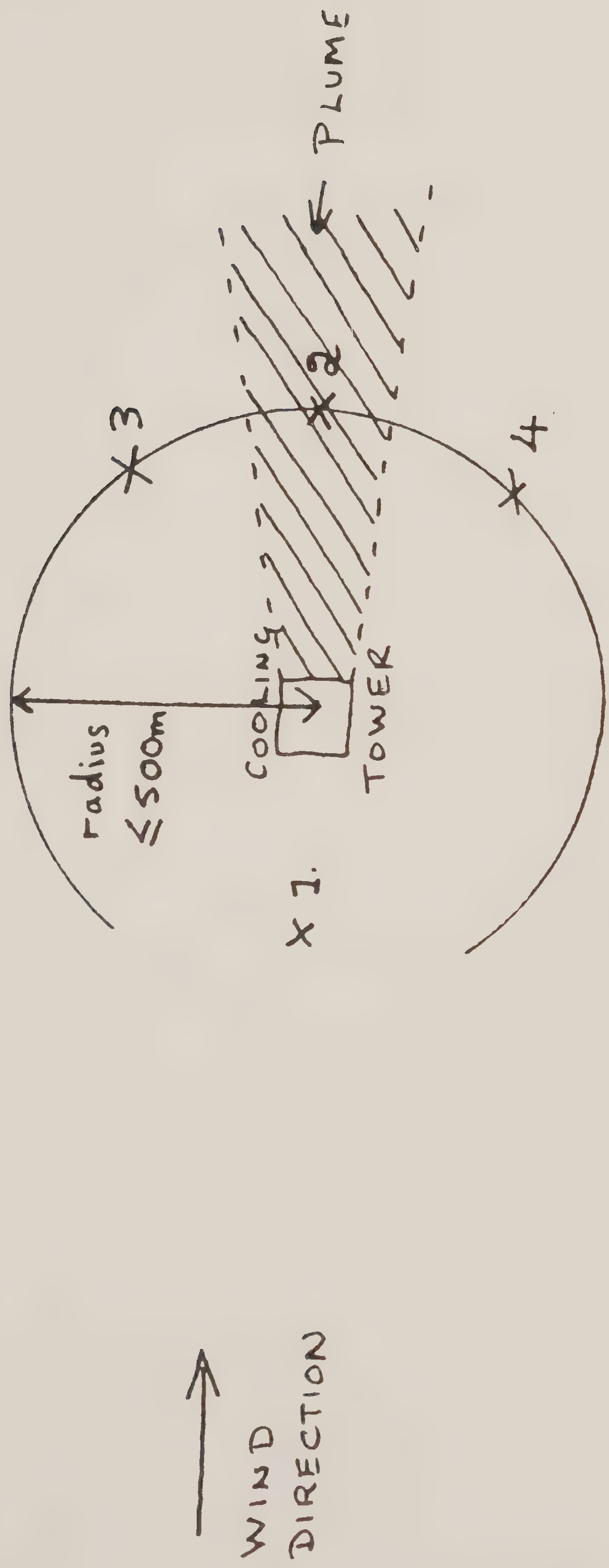


Fig. 6

D. Penfold
National Power

Following Mr. Parkinson's paper, Mr. Penfold responded as follows:

First of all may I, too, congratulate Nevil Parkinson and his colleagues at Selby on a very detailed, thorough presentation on the workings of natural draught cooling towers and on their environmental impact. I am very grateful to you, Mr. Chairman, for allowing me to respond on behalf of National Power on a few of the issues.

I feel that I am setting, perhaps, a departure from the Conference; I must be the only person to stand up here who isn't actually a member of the "club" - the only person who is actually defending anything here.

Regarding the incident in October 1989, all we can say is that within National Power we did get quite a number of things wrong at that time, and I would like to concentrate not on what went wrong at the time but on what we have done since. The sedimentation plant was not designed to cope with the high silt levers. We got a very dry summer in 1976 which the experts told us was a once in a hundred years occurrence. It happened again in 1989, and it has happened again this year. As Mr. Parkinson says, silt levels of 70,000 - a very, very thick mixture. We have got a sedimentation plant producing an outlet water of between 50 and 100 ppm silt consistently. We carried out a thorough programme of cleaning the cooling towers; the whole system has been cleaned up since last year. The plastic eliminators have been removed and replaced with wooden eliminators in all the towers which had plastic eliminators installed. We have set up a routine inspection programme for looking inside the cooling towers monitoring continuously, fouling of the packing and looking for any damage to eliminators. We have taken you round the station, Mr. Parkinson, shown you what we have done, and that too has been reported in the local press.

We can turn now to the subject of eliminators. It is being suggested that if we used better eliminators we might get less carry-over, less of a plume problem. It has also been suggested that the eliminators have not been tested. We are using an accepted and established design of eliminator. A number of them have been re-tested by the suppliers - we are building on an experience of that design. We are also at the moment carrying out in-tower measurements on the drift above the eliminators at Drax, and that work is being set up. The

British Standard does not specify an actual drift flux above the eliminators in milligrammes per square metre per second or whatever. It specifies an absence of a certain rain-out level, given as 25 microns per hour. The experience that we have, going back to the early 1970s, up to the present is that we do not get that sort of high rain-out level now except in the very immediate vicinity of the cooling towers.

In your paper, Mr. Parkinson, you say that that sort of rainout is not experienced at relative humidities below 60 per cent RH. That would in fact cover quite a large proportion of the time, and if you go back to the paper by Martin and Barber in 1974, you will see that there is no incidence of higher rainout less than 90 per cent relative humidity.

We can turn now to cooling tower plumes. If you walk round the exhibition hall you can see at least two pictures of cooling tower plumes. Mr. Parkinson showed a few as well. If you photograph a cooling tower plume with the light behind it, it looks grey, and if the sun is right behind it it looks black; you can get Ringelmann 5 coming out of a cooling tower if you take it with the right exposure and the sun in the right place. But in reality, what you are seeing is a lot of condensed droplets. The same phenomenon on a dirty wet day - if you look at the sky it looks grey or black; if you fly above it in an aeroplane it looks white. It depends whether the light is being reflected from it or is stopped from going though it. But what you see in a dense cooling tower plume is largely the condensation of vapour; so if you see a heavy cooling tower plume, that big, heavy plume is not river water; it is not even treated river water; it is largely condensation providing a very large surface area of droplets. With regard to the health aspects of cooling towers - I do not want to open up the debate on Legionella because we would be here all afternoon just setting the scene for that. I would like, however, to make the point though that one must distinguish very, very carefully between, on the one hand, the incidence of Pontiac fever, or condensing cleaners' disease, experienced by people working within condensers or within the cooling tower, and on the other hand the very distinct and separate risk to the public or to anybody outside the cooling tower.

So, if I may conclude, Mr. Chairman, there are three points I would like to make: first of all, that cooling towers are generally, and have been for a long, long time, a fact of electricity power generation, certainly on inland power stations. We do not see them as a major environmental problem. Regarding the health risk, there is a consensus between ourselves, the district council and academics, that for the majority of the time, perhaps 98 per cent of the time,

there is no risk to health. We feel that there is no risk to health at all, and we are actively trying to demonstrate that there is no risk to health in that remaining 2 per cent of the time. Thirdly, all of you must be aware from the depth and breadth of Mr. Parkinson's paper that Selby Council have made a major effort on the subject of cooling towers. It will be less obvious to you, and I would like to reassure you that National Power too have made a very great effort to try to understand, to clarify and to improve the operation of cooling towers, particularly at Drax. So if I can leave you with one final message on this: National Power do care about the environment, and they do care about how they operate their cooling towers.

NEW POWERS FOR LOCAL AUTHORITIES

INTRODUCTION

Mrs K. Hunt
Air Quality Division
Department of the Environment

Neil Sanders was unable to attend the Conference due to ill-health. Session 7 was introduced by Mrs Kay Hunt.

The Department is delighted to be here at the Conference today shortly before the introduction of the new powers for local authorities under Part I of the Environmental Protection Bill, and to set out the new air pollution control system which is being formulated in the Bill. The Bill has almost finished its parliamentary stages - it is still in the House of Lords and about to finish report, will then go to third reading, and back to the Commons for consideration of the Lords' amendments and hopefully will get Royal Assent in early November.

Our timetable for introduction on the local authority side is now very rapid. We will be introducing about a third of the processes from April 1991; all the other processes for local authority control will be brought into the new system in two more batches in October 1991 and April 1992. All authorisations will be due by local authorities by the end of October 1993. So within a very short period of time all Part B processes scheduled for local authority air pollution control will have come under the new system.

The guidance notes from the Secretary of State to local authorities on the appropriate levels of controls for each of the classes of process which are to pass to local authorities are well on schedule. All the notes for batch one are just about to go out on final circulation and will be ready for publication early in the New Year. We are extremely grateful to all those local authority officers and industrialists who sat on the working groups and assisted with drawing up these process guidance notes.

It is an ambitious implementation timetable - Martin Bigg will talk a little more about it, and I think Steve Bassam on behalf of the AMA is going to be raising questions about resources and the local authorities' state of readiness. I think the session sounds as if it will be extremely interesting and challenging. I hope it will also be useful to you all.

One of the points raised this morning in Nevil Parkinson's paper is I think extremely relevant to the sort of controls that we are introducing under the new system. The point related particularly to public consultation, the information that will be available to everyone - both about the controls to be imposed by local authorities and the controls to be imposed by the Inspectorate in relation to integrated pollution control. The sort of problems we were hearing about concerned individuals and local authorities who were unhappy with the level of control that was being exercised and knowledge about the way the control system was being implemented and policed. Under the new system I think this will be much more visible and readily apparent.

NEW POWERS FOR LOCAL AUTHORITIES

IMPLEMENTING THE GREEN BILL

Dr. M. Bigg
HM Inspectorate of Pollution
Local Authority Unit

Summary

In addition to the introduction of integrated pollution control, the Environmental Protection Bill contains proposals to give local authorities prior authorisation and enforcement powers over a middle tier of industrial processes for air pollution control. The preparation for the new powers and control regime will be discussed.

Introduction

The Environmental Protection Bill has now almost completed its passage through Parliament. A number of its parts concern pollution control including new powers over waste and litter. This paper is primarily concerned with Part I which covers integrated pollution control and air pollution control by local authorities.

Part I of the Bill enacts many of the proposals set out in consultation papers on integrated pollution control, air pollution control systems, charging and access to information. The Bill sets up integrated pollution control for the National Inspectorates (Her Majesty's Inspectorate of Pollution in England and Wales and Her Majesty's Industrial Pollution Inspectorate in Scotland) and local authority air pollution control throughout Great Britain. The provisions for Scotland were added at the Committee stage in the House of Commons.

Main Features of Part I of the Environmental Protection Bill

The Secretary of State is empowered to prescribe processes and substances for integrated pollution control or local authority air pollution control and to set environmental quality objectives, emission limits and other controls for the processes.

The concept of "best practicable means" as used by the National Inspectorates in relation to gaseous emissions for the past, approximately, 125 years is replaced by "best available techniques not entailing excessive costs" (BATNEEC).

A system of prior control is established by the need for a formal authorisation before a process can begin to operate.

These authorisations will contain specific conditions that are binding in law and a residual duty to ensure that BATNEEC is used in relation to any aspect of the process that is not covered by a specific condition.

The objectives in the granting of each authorisation are to ensure the use of BATNEEC to:

a. prevent the release to air, water or land or any combination of these of any substance that has been prescribed for that medium or, where that is not practicable, to reduce the release of such substances to a minimum;

b. ensure all releases, whether or not prescribed, are harmless to people, their property and the environment;

c. comply with any relevant Regulations, for example, on emission limits and environmental quality objectives.

d. comply with relevant directions by the Secretary of State;

e. comply with any environmental protection plans set by the Secretary of State, for example, to implement the EEC Large Combustion Plants Directive.

For processes coming under integrated pollution control (IPC) the best practicable environmental option (BPEO) must be used where there is a potential for release of prescribed substances to more than one medium.

The Pollution Control Authority has been given a variety of enforcement powers.

<u>Enforcement Notice</u>: This has its origins in HMIP's practice to issue infraction letters. It sets out what the operator must do.

<u>Variation Notice</u>: This provides a means for upgrading the process to meet the requirements of BATNEEC.

<u>Prohibition Notice</u>: This is similar to the current Prohibition Notice under the Health and Safety at Work Act 1974. A Prohibition Notice must be served in cases where there is a risk of serious pollution of the environment.

<u>Revocation Notice</u>: This may be used when a process is closed down for one year or more, in cases of non-payment of the annual charge, or where the controls in

the Bill are flagrantly disregarded by an operator.

The operator can appeal to the Secretary of State against conditions of an authorisation, its non-determination within 4 months, or any Notice. Appeals will not put the authorisation or Notice into abeyance, except the Revocation Notice which effectively terminates an operator's business.

All applications for authorisation must be advertised in a local newspaper and confirmation that the advertisement has appeared given to the Pollution Control Authority. The advertisement should explain where full details of the application are available so that the public can comment before the process is authorised to start operation or undergo a significant alteration.

Public registers must be set up in local authority offices giving details of all integrated pollution control and local authority air pollution control processes in the area. These will contain information on the applications for authorisations, the authorisations themselves, any Notices issued, directions by the Secretary of State, appeals, convictions and monitoring data. Very limited restrictions on availability of information are allowed to protect items of national security and commercial confidentality.

Standard charges will be levied in line with a national scheme to recover the cost of the pollution control authority's activities in implementing the legislation. There will be a charge for the initial application for an authorisation and an annual charge.

Local authority and national inspectors are given extensive powers of entry, inspection, sampling, investigation and seizure of articles which cause imminent danger of serious harm. Where an offence has been committed the Court can order the offender to remedy it and, if so directed by the Secretary of State, the Chief Inspector may arrange for it to be remedied at the offender's cost.

Consistency of Control

Under the currently proposed schedule of prescribed processes there are approximately 80 destined for local authority control covering about 12,000 individual installations and a further approximately 15,000 waste oil burners. All the new processes, substantially changed processes and existing processes are proposed to come within the new controls in 3 groups with the first group of processes applying for an authorisation from 1 April 1991.

For processes proposed to come under local authority control several types of guidance are being produced. These guidance notes will be issued by the Secretary of State to local authorities.

i. <u>General Guidance</u>

This series of notes contains guidance on the operation of the local authority air pollution control system:

a. General interpretation of legislative requirements and enforcement.

b. The content of authorisations and the drafting of appropriate conditions.

c. Applications and registers.

d. The interpretation of phrases and terms in the process specific guidance note.

ii. <u>Technical Guidance</u>

These notes provide technical information to back up the process specific guidance:

a. Chimney and vent height determination.

b. Appropriate available abatement and arrestment equipment.

c. Environmental monitoring for particulate matter and chemical pollutants.

e. Sampling protocols.

iii. <u>Process Guidance</u>

These notes will be produced in advance of the processes coming under control. The formal consultation on several of these notes is already under way. In each case the following points have been addressed:

Emission limits and controls

Monitoring, sampling and measurement conditions

Materials handling

Process control

Arrestment plant

Chimneys, vents and process exhausts.

Conclusions

A whole new area is proposed to be covered by the Environmental Protection Bill. The legislation is expected to set up the new two tiered system of integrated pollution control by the national Inspectorates and local authority air pollution control. If the legislation and its interpretation are to be workable and acceptable then there must be consistent enforcement by the pollution control authorities. The success to date in the production of the guidance for local authorities is directly attributable to the support and co-operation received from local authorities, industry and other interested groups.

NEW POWERS FOR LOCAL AUTHORITIES

POLLUTION CONTROL: HOW CAN LOCAL AUTHORITIES MEET THE CHALLENGE?

S. Bassam
Association of Metropolitan Authorities

In my paper I hope to examine two things: firstly, the environmental challenge posed to local authorities in the current Environmental Protection Bill and secondly, the nature of the new challenges around the corner as political expectations on environmental performance rise.

First let us begin by taking a look at the promise and the challenge of the Government's current piece of legislation and what it means for us in local Government. Of the EPB, there are four sections with major implications for local authorities. These are:-

> **Part I** which introduces Integrated Pollution Control;
>
> **Part II** which introduces a new management regime for Waste and a Duty of Care;
>
> **Part III** which updates and consolidates statutory nuisance powers, and
>
> **Part IV** which introduces new powers, duties and responsibilities for local authorities tackling the national problem of litter.

The remaining parts of the Bill do have some implications for authorities, but do not create any of the challenges and opportunities on the same scale, so I will not deal with them in any great detail.

Integrated Pollution Control

Part I sets out what the Government sees as a system for IPC properly according inspectorate and enforcement functions to the HMIP and local authorities. The system introduces a new principle for IPC for industry which covers major emissions to air, land and water. It requires that a person proposing to operate a specified process obtain a prior authorisation from HMIP containing specific conditions which must be met in carrying out that process. The objective is to prevent or minimise the release of the most potentially polluting substances and require all substances that are released to be rendered harmless.

Part I also makes local authorities the agencies of enforcement for air pollution from a second tier of less polluting processes. Working within parameters laid down by the Secretary of State, local authorities will only permit processes to operate after imposing conditions necessary for proper pollution control.

Critique

It is accepted by Government that HMIP is under-resourced and that morale within the service is low. Significant doubts exist as to whether HMIP will be able to operate effectively the new powers. Extended local authority powers are welcome but we are not yet confident that resource implications have been effectively estimated for training and monitoring. Indeed one of the Ministers, Michael Portillo, recently commented that "the 'cost recovery' charging system ... will provide local authorities with the means to undertake their new functions in a full and comprehensive manner."

Local authorities are not so confident. Initial estimates from the Department of Environment suggested we would require just £0.5m in income to cover the cost nationally. Latterly and following Association level consultation a more realistic fee charging proposal emerged with £800 for applications with scheduled processes and £500 for the annual fee. I am confident that authorities will be asking for more come next year. This system is fine as far as it goes, but cost recovery does not take account of training and start-up costs and we know of authorities who are already spending money in preparation for the new powers within the IPC regime.

There are, too, the questions of displaced departmental activity and the lost opportunity cost. What has not been resolved either is how professional and technical responsibilities will be phased out as environmental health departments learn to cope with the new powers. We welcome the new responsibilities for air emissions from the range of less polluting processes and the integrated approach. But we also take the view that local authorities will have a better knowledge of their own areas and will have current and historical background information not necessarily available to the stretched services of HMIP on water and land uses. A revision of responsibilities ought in our view to take place; this could also discuss the idea of developing local authorities as a source of agency support in undertaking some of this work for HMIP? At a price of course, and where the expertise can be developed or it already exists.

Part I of the Bill also introduces into the legislative arena the concept of Best Available Techniques Not Entailing

Excessive Costs (BATNEEC) as a means of minimising pollution. Our view is that it is essential that precisely formulated definitions of this system and concept are refined if it is to be adopted in the UK. During the parliamentary debates no clear Government vision emerged spelling out the meaning of BATNEEC. Concern has been continually expressed as to whether the term 'available' will be interpreted as meaning 'commercially available' and 'excessive cost' interpreted too generously in favour of the polluter.

There must be considerable concern that while the 3,500 or so 'scheduled' processes and an unquantified number of 'less polluting' processes are covered in the EPB, the wider ranging sources of nitrogen oxides, carbon dioxide, methane and sulphur dioxide have not been addressed. These have serious consequences for the problem of global warming and there are no indications as yet that Government is addressing these issues in this Bill or in the White paper with the seriousness they deserve.

Perhaps the simplest possible positive action would have been to promote serious energy conservation measures, encourage thermal insulation, heat transfer systems and stimulate research and development of renewable energy sources. Finally on this, it would have been a great step forward if we had national policy making which could be translated locally into planning locally.

In welcoming the introduction of IPC concept and BATNEEC we have sadly to question at a fundamental level their commitment. HMIP has been shamelessly starved of resources. I hear dark mutterings about the Local Authority Unit and its future and the future of IPLA, the liaison body set up by HMIP with local authorities. This despite its problems with cash and confidence has been most useful, providing a vital link between Local Authorities and the HMIP, which over time has proved its worth. Any diminution in its role, function and purpose would set local/national environmental working relations back just at a time when progress and improvement has been made.

Waste on Land

Part II of the Bill dealing with the law on waste suffers from similar problems to Part I. It contains the germ of a useful idea, but has at its heart an altogether different objective. The effect is to repeal parts of the Control of Pollution Act 1974 and provide additions and modifications. The major change is the introduction of a 'Duty of Care' on those who produce or handle waste to ensure proper disposal. It also

re-organises the local authority waste management function. This involves a splitting of functions and the creation of 'arms length' waste disposal companies. Amongst the detail of Part II is the replacement of waste disposal licensing by waste management licensing. This ought to provide a greater potential for controlling pollution through waste. Licenses will remain in force until disposal sites are made safe and aftercare measures completed.

Responsibility for monitoring and ensuring that the landfill sites are safe will become a duty of waste regulation authorities. One useful power that is contained in the Bill provides for licensing authorities to take account of broader considerations when considering an applicant's fitness to hold a licence. Authorities will be obliged for the first time to produce plans for waste recycling and to publish those plans.

Critique

Our Association's principal objection to Part II rests with the dismembering of the local authority waste management function. What surprised us was the lack of prior consultation on this measure. As recently as 1989 the HMIP reviewed arrangements and concluded that no change was necessary. We can see no basis for the assumption that the separation of regulation from waste disposal will lead to improved standards. Why, for instance, is the Government content with the arrangements remaining as they will in Scotland, but obliging local authorities to create LAWDCs in England and Wales? Is it, as we suspect, simply a precursor to the full scale privatisation of waste disposal as part of the Government's next step?

On a positive note, we welcome improvements to the control of waste contained in the legislation, particularly with the 'duty of care' and the development of a registration scheme for producers of waste. We believe this is the only way a genuine 'Birth to Earth' control system can be properly managed. We are however concerned that the penalties for breaches of pollution control, though increased, leave original offenders able to make cost benefit equations at the public's expense. Pollution offences should have stiffer penalties which mirror the cost of the damage and its long term impact.

The biggest deficiency in the Bill's waste management arrangements is undoubtedly the lack of a coherent planning structure for waste management. The arrangements will leave

the planning function with a range of authorities - in our experience this cannot lead to improved control and management.

The Bill fails fundamentally the environmentally friendly test on waste management, reclamation and recycling grounds. Indeed it falls so far short of public expectations that local authorities are bound to conclude that in many ways current practice is better than Government policy and that where it is deficient local government should step in and take a lead in creating a national recycling plan and strategy for recycling, reclamation and waste minimisation. The AMA has argued that a set of enforceable national standards with an objective to work to is a way forward. Moreover the legislation lacks any recognition of the work which local authorities have been undertaking in this field for more than a hundred years. It also fails to recognise the quite perverse way in which the market operates to skew fundamental policy objectives in recycling initiatives.

We believe that recycling is a sufficiently desirable policy objective, that we need a national plan to be achieved through a mix of incentives, requirements, taxes and penalties. Government must have a role in orchestrating this and providing enabling legislation to overcome the limits of market forces. But we await that lead.

Statutory Nuisances and Clean Air

Part III of the Bill is probably the least controversial. it aims to consolidate and update the law on statutory nuisance including the abatement of noise nuisance. Procedures used by local authorities to abate nuisance will be simplified. Welcome new powers are to be granted to local authorities, enabling action in anticipation of nuisances occurring, with some useful clarification of what constitutes a statutory nuisance. Part III also provides for regulations to be made to extend control over smoke, grit, dust and fume emissions.

While Environmental Health Officers will not disagree with the content of this part of the Bill, what they will object to is further new demands on scarce staff resources. On their own the statutory nuisance clauses will not cause staff problems, but taken with the new burdens placed on them with Parts I, II and IV, the Countryside Commission and Nature Conservancy Council clauses, those on GMOs and stubble burning, they amount to a sizeable impact on local authorities.

Litter

But what of Part IV? This is arguably one of the more interesting and controversial aspects of the Bill's pollution control measures. Interesting because it is so clearly part of a series of measures demanded by the Prime Minister, chasing one of her obsessions. Controversial because the Government in its infinite wisdom has chosen to impose upon local authorities a barrage of powers, duties and reponsibilities, which could prove extremely costly. The measures, although welcomed in spirit by local government, are a classic example of how not to introduce an idea into legislation without first thinking through the consequences and talking to managers of cleansing services in local government. Apart from stiffer penalties for littering, duties to keep land clean and the right of an aggrieved individual to seek an abatement order, litter control notice powers on commercial premises, the Government has drafted a 'Code of Practice' under powers given to the Secretary of State in Section 86.

This code has brought the litter clauses into disrepute because of its failure to recognise the realities of a cleansing operation and because it fails to address the real problem with resources. It seeks to create seven categories of local authority areas and set four standards of cleanliness for those areas, which have to be kept to the standards over a pre-determined time period. Apart from being hoplessly and wastefully mechanistic, if carried out to the letter it becomes very expensive.

Back in the spring the local authority associations asked for an additional £250m to £350m to meet the standard. The Government rejected this and said it would be met within the savings achieved through CCT. They did however suspect they might have a problem and decided to appoint Cooper and Lybrand Deloitte as consultants to examine implementation costs. Coopers undertook a survey of just seventeen authorities, including two County Councils. Their study revealed a cost increase with parameters between 10 per cent and 30 per cent. This prompted the Minister David Trippier to say that there was no cost problem. The AMA looked at the detail of the Coopers Study and decided to conduct its own survey.

The initial figures which we released over a month ago suggested a minimum increase of 31 per cent or £100m nationally, adding £3 to the average annual poll tax bill. Our more detailed second look at figures suggests a 61 per cent increase or likely £200m rise in cleaning costs, with £6 on the average poll tax bill.

In the seventh revised draft of the code a Tidy Britain Group (TBG) proposal added to the AMA's concern on costs. TBG were suggesting to the DoE that in Category A areas bins be placed every 18 feet and in cateegory B areas every 50 feet and Category C areas every 75 feet. Apart from the litter bin manufacturers and I dare say a few unemployed street cleaners, few in local government saw much wisdom in the proposal. Indeed, I suspect if carried through the scheme would have turned our high streets into obstacle courses for pedestrians, rather than litter free zones.

The Association trial to get costings for this, and those authorities who took it seriously were quoting bin provision figures at a minimum of ten times the current level and cleaning costs nearly doubling the national spend on cleaning. The Government late in the day has distanced itself from the draft and Lady Blatch said in the Lords debate this week, and I quote, 'was not government authorised ... and no longer appears in the code'. She also claimed that the Association's figures were 'based on an out of date version of the code.' Clearly the Government are rattled and realise that another Prime Ministerial obsession would cost and not necessarily bring any real benefit in terms of reducing litter pollution.

Belatedly the Government has also recognised that the Code will mean contractual re-negotiations with both DSOs and private cleaning operators, since few specifications match the 'Codes' quality standard. Such is the muddle that the next two deadline dates for letting contracts have been set back eight months and a hurried amendment forced through to protect private sector tendering interests and place re-tendering pressures on authorities. None of this has much to do with keeping our streets clean or providing a good quality service.

Implications for Local Authorities

With all that is facing local government - Poll Tax, compulsory competitive tendering, new financial controls, new legislation on food safety and European legislation, I am acutely conscious that the Environmental Protection Bill is likely to be seen as yet one more irritant to be gone through. Against this background, what can be expected of its impact?

In the short term, sadly very little. The IPC section, because of resource constraints with HMIP and within local government, the new regime will take time to work. Similarly, I strongly suspect the litter clauses will be slow to bite - not least because of practicality problems and the terrible entanglements created for authorities seeking to renegotiate contracts and arrangements with private operators and DSOs. if our figures are right, most authorities conscious of Poll

Tax levels will find it hard to resource the new service standards sought by Ministers.

With LAWDCs too there will be problems. As yet - as with most of the Bill - there are no implementation timetables established and the Government is busy delaying the introduction of sections because of the cost implications. Guidance is due to be published in October this year, with implementation due probably on a rolling basis from, I suspect, November 1991 at the earliest. We are deeply suspicious of the purpose behind this section.

While it is likely that monitoring will improve, the companies themselves look to be designed to fail. The likelihood is that arm's length operations operating within the local authority capital control system will be each starved and then opened up to predator bids and offers from the private sector. Big questions like who will compose 80 per cent of the Board's membership, and how will they be selected and endorsed, remain unanswered. Against this background, can we expect the LAWDCSs to succeed? - the experience of arm's length bus and transport undertakers does not inspire great confidence.

The statutory nuisance clauses in Part III of the Bill will have an impact because they are likely to generate more demand, particularly on noise pollution. Their impact is harder to discuss, because the clauses re-enact the 1936 Public Health Act and strengthen it. Quite how departments will cope, I am not certain, especially since they will be simultaneously dealing with the multiple impact of changes in housing, food and environmental protection legislation. Currently estimates suggest the public sector is short of 400-500 environmental health officers, demands for extra staff will inevitably grow and yet the supply of trained and qualified staff is not likely to substantially increase. Perhaps there is scope for changes in professional disciplines and a re-organisation using technical support staff - but this will have major implications for employment practices and institutional boundaries.

Certainly within counties, some joint bodies and the metropolitan authorities, some re-organisation will occur as client and contractor functions are extended with LAWDCs and litter enforcement. The monitoring of waste management and operation and the litter and street cleansing will require new skills to be developed and functions strengthened. Legal departments will take on more contracted drafting and enforcement work and administrative procedures with licensing and registration will require additional support. Much of this has yet to be quantified and must pose questions about the Bill's practical achievability.

In all of this one thing is for certain, and that is that public expectations have and will rise whatever the Bill's impact. I take the view that we in local government should not be frightened or fearful of that likelihood. Instead we should see the Government's initiative as an oportunity, for however weak the Bill's measures and misdirected its targets, it does raise the issue.

Local government is well placed not just to respond but initiate and set the environmental agenda. Indeed the evidence from our authorities with their environment charters, performance audits and policy commitments on everything from recycling through to global warming and the greenhouse effect suggests this is already happening.

What is perhaps missing is a clearer framework for local authorities to work within. Consequently the AMA and now the ADC have policies which call for the creation of local authorities as statutory environmental protection agencies.

The recognition that such a move would give to local authorities, who are both providers and protectors in the environment field, would be a necessary and renewed sense of purpose. Moreover, it would help bring a more coherent and planned approach to tackling environmental degradation and environmental investment. What we find lacking in the Government's approach is a sense of direction. The 'green' bill is a disappointment. It creates no new structure for independent assessment of environmental concerns or means of enforcement. It contains no reference to a national strategy linking transport, waste, energy use and pollution and it does nothing of depth to empower the people and communities who are already using their purchasing power and campaigning energies to influence the future of their national and physical environments.

I said earlier that we need to think forward to the environmental challenge beyond the current Bill.

In the last month there have been two highly significant policy documents published - firstly the Government's White Paper *This Common Inheritance,* and only this week the Labour Party policy document *An Earthly Chance*.

The difference in emphasis is sharp for local government. The White Paper is long on analysis with plenty of exhortation and words like 'promote', 'consider, 'might' and 'encourage' and short on attainable actions and timetables. As for local government its place is, as ever, understated. We finally get a mention and much praise on the last page of the final chapter and only half a page at that. Who would believe that

we have been entrepreneurs in environmental protection for over a hundred years. The paper does say however: -

'local authorities have a key part to play in environmental policies. Not only do they have a range of specific powers and functions which have a direct impact on their local environment, but also as with Government Departments almost everything which local authorities do has some impact on the environment. The best local authorities have an enviable environmental record and are pioneering ways of co-ordinating their environmental strategies and activities on a corporate basis.'

It is also proposed that there will be dialogue meetings betwen DoE Ministers and the local authority associations, on common issues of concern.

What disappoints in the Government approach is the lack of a cohesive, corporate and structured way of taking environment policy forward. There is no dedicated Ministerial impact, no Environment Commission, no enforcement, and finally no planning structure looking to the future. There is however a new certainty that we in local government can expect to be told to carry out environment improvement and enforcement, that legislation will come foreward just as it has with the current Bill. I am not certain, having looked at the 'challenge' of the White Paper, that we won't get set again a series of environmental obsessions rather than priorities.

By contrast the Labour party policy does have a strategy with key commitments and structures to carry out the environmental task and priorities. Moreover it it clear that it wants the best mechanism used to achieve objectives. It is not stuck with using just the market of regulation. It seeks to use whatever can best be deployed to attain a desirable environmental goal.

Ultimately the environment should be above ideology because its safe custody for future generations is in our gift, and we will not be thanked for perpetual and unsustainable abuse. Whatever Party is in government as we approach the next century, one thing is for certain - we in local government will be faced with meeting its challenges, its agenda; our duty is to serve, to be critical and perform. That is a challenge we must be ready to meet.

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THE POLITICAL CHALLENGE

19 September 1986
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ACID RAIN – THE POLITICAL CHALLENGE

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ACID RAIN - THE POLITICAL CHALLENGE

INTRODUCTION

On Friday 19 September 1986 a major conference on Acid Rain, sponsored by the Commission of the European Communities and organised by the National Society for Clean Air in conjunction with the Institute for European Environmental Policy, was held in London.

The event coincided with the UK Presidency of the EEC, when environmental policies were under particular scrutiny in the wake of decisions taken by various EEC Member States to press ahead with action aimed at achieving substantial reductions in atmospheric emissions. A number of EEC countries had indeed made binding commitments under the UN ECE Convention on Long Range Transboundary Air Pollution, and its associated Protocol that requires signatories to reduce emissions of sulphur dioxide by a specified amount. While the UK was not so committed, just a few days before the conference the British Government had announced a limited programme of action aimed at reducing the UK's contribution to acid deposition.

The Conference brought together high level decision makers, including those with responsibility for energy and environmental management in industry. It provided the opportunity to review the UK position in terms of overall European Community aspirations and compare the approach in other countries, specifically the United States, Sweden and the Federal Republic of Germany.

Stanley Clinton Davis, the European Commissioner with responsibility for environmental policy, set the scene by highlighting the divergence of attitude among EEC Member States on the measures necessary to arrest the damage caused by acid deposition. He spoke of the major political challenge this represented for Europe as a whole and especially for the European Community - with its commitment to environmental protection and to the harmonisation of legislation and of the conditions of competition.

The Conference generated considerable debate on the political issues raised by acid rain within an international context, but the scientific background was also thoroughly reviewed. Lord Marshall of Goring, Chairman of the Central Electricity Generating Board, discussed the new scientific findings which lay behind the Board's recent initiative on flue gas desulphurisation and other measures to control gaseous emissions from three existing power stations. William Waldegrave, the UK Environment Minister, outlined the position of HM Government but also looked at the broader issues from the perspective of his then role as President of the EEC's Council of Environment Ministers.

Sir Hugh Rossi, MP, presented the view of the House of Commons Environment Committee, highlighting developments which had influenced its thinking since the Committee's original report on the subject was published in 1984. The conference then received scientific and policy reviews from Konrad von Moltke of the Conservation Foundation in Washington, Goran Persson of the National Swedish Environmental Protection Board, and Mrs. Beate Weber, MEP, Chair of the European Parliament's Environment Committee. Mrs. Weber spoke from the perspective of both the Federal Republic of Germany and the European Parliament.

The day ended with a debate in which all the speakers took part (Dr. Martin Holdgate substituting for Mr. Waldegrave), with the additional participation of Simon Hughes, MP (then the Liberal Party Environment Spokesman) and Mr. David Clark, MP, Environmental Protection Spokesman for the Labour Party. Dr. Clark wound up the debate at the close of the conference which had been expertly chaired by Ken Collins, MEP, in the morning and The Rt. Hon. The Earl of Cranbrook in the afternoon. The organisers are deeply grateful to the chairmen and to all the speakers, who between them made the event a considerable success.

EDITOR'S NOTE

The original intention was to publish both the papers and an edited transcript of the discussion during the debate but regrettably preparation of a full record of the proceedings proved to be impossible.

ACID RAIN : THE CHALLENGE FOR EUROPE

by
Stanley Clinton Davis
Member of the Commission of the European Communities

This year the twelve Member States of the European Community will pump into the atmosphere more than 18 million tonnes of sulphur dioxide. It will fall to earth as acid. To make matters worse, they will strengthen the potion by adding more than 10 million tonnes of nitrogen oxides. More acid.

This acid drench is a destroyer. It poisons land so that trees don't grow. It poisons lakes and rivers and fish disappear. It eats away monuments and buildings. With every day that passes, more is lost.

Stopping this destruction has become a political imperative. In 1983, the Heads of Community Governments called attention to the dangers. Since then, action against acid rain has been a dominant theme of the Community's policy for environmental protection.

It takes many forms.

- Last year Ministers argued through three all-night sessions in an effort to agree more stringent norms for car exhaust gases, in particular for nitrogen oxides.

- More recently, they have spent hours on attempts to reduce the amounts of sulphur emitted from coal and oil-fired stations.

- In addition, work is going on to reduce the permitted sulphur content of central heating oil; to control the burning of waste oils; to reduce exhaust emissions from lorries and diesel cars.

These measures would add up to a major legislative programme. They would add up to a real and effective reply to the demand for action made by the Heads of Government. But despite big words, despite the widening perception that we are heading for an avoidable disaster, progress has been slight. Governments still hesitate.

Yet, the longer we wait, the longer we stand bemused before this political challenge, then the bigger the problem, the bigger the bill and the more drastic the remedies that will be required.

One reason for the hesitation is that the political challenge posed by acid rain is complex. It means spending money on a problem before we fully understand the processes of cause and effect. It means spending money in one country for benefits in another. It means investing today for benefits in the next century.

There are many bolt holes for those who do not want to take decisions. One of the surest is to plead ignorance, to plead that we do not have sufficient knowledge on which to base policy, that what we really need is more research.

It's true that we do not fully understand the phenomenon of acid rain. We do not fully understand how nitric oxide from car engines or sulphur from coal-fired power stations kills trees. But we know enough.

We know that there is a direct link between emissions of sulphur and nitrogen oxides and acid deposition. We know that we are pumping more acid into the environment than it can neutralise. We can see the damage. We know what action we should take.

Obviously we need more research, into causality, into ways of reducing our emissions, into ways of making good the damage. But the research should be a complement to action, NOT a substitute.

Then we come to the difficult question of who benefits from money spent on preventing acid rain. We come to that indefinable quality of solidarity.

Our experience over the last few years points to one conclusion. If all this acid rained on the country that caused it, the problem would have been solved by now. But it doesn't.

Five Community countries are responsible for 85% of the sulphur dioxide we pump into the air from power stations. But they do not suffer from 85% of the acid. Instead it is carried away on the wind: pollution does not stop at frontiers.

Part of the political problem is to convince the damage exporters that they must spend money to help others. That they must give up illusory short-term gain to protect the quality of life elsewhere.

It is not easy. They are not convinced and look for reasons not to take action. Special pleading abounds..."We have already reduced our emissions; we cannot afford higher electricity costs; we cannot afford to develop new motor car engines; we cannot ..." What they are really saying is "As long as the wind blows it your way, Jack, I'm all right."

Recently, the United Kingdom Government made a commitment. It announced that it has authorised the Central Electricity Generating Board to retrofit the equivalent of three 2,000 megawatt coal-fired power stations over the next 12 years.

As the Member of the European Commission responsible for environment policy, I am pleased to note this new approach from the United Kingdom. And I say: Let that be a first step. Let that be the beginning of an accelerating programme. Let us see that it is a sign of real political commitment.

Focus on the advantages and not the problems. Focus on the possibilities of developing and selling new technologies. Focus on the possibilities of cleaning your own environment which is suffering from acid rain. Focus on your friends inside and outside the Community and their needs.

And then there is the third point that makes this challenge posed by acid rain so complex - the question of the delayed

return; the view that we are investing today, in the midst of an economic recession, for benefits in the next century.

It is true that the environmental benefits will not come overnight. Just as the damage to trees, lakes and rivers was slow to appear, it will be slow to disappear. All the more reason, the Commission says, for acting now.

But there will be some rapid benefits - both for the environment and for the economy. Once we know we are stopping the pollution at source, we can more confidently begin to replant forests, restock rivers and lakes and restore monuments. We must also recognise that there will be economic benefits - they may be difficult to quantify but that does not mean they will not exist.

Much of our post-war prosperity was based on the view that strategic investment made by the government of the day could create self-sustaining jobs. This was an essential component of Keynesianism which seemed to go out of fashion a few years ago. But in or out of fashion the underlying truth holds. Investing in the quality of life will bring tangible economic benefits.

Like so many environmental problems, the fight against acid rain is tied in with questions of short-term economic gain. It is almost exactly parallel, for example, to the destruction of the tropical rainforests, something which provides a quick return but at the expense of the future.

It's time to look at the issue in another way. It's not a question of 'live now, pay later', versus 'pay now, live later'. If we are intelligent we can live with quality now and later. Let's be intelligent.

Meeting the challenge is a question of finding the right political balance between competing claims. So far the Community and some Member States have got the balance wrong.

It is true, of course, that the Community has reached a near agreement on a new regime for motor vehicle emissions. But the regime is not yet fully agreed, largely because one Member State thinks it does not go far enough in the

direction of environmental protection.

I have sympathy with that view. But I believe that the rule of political balance acts both ways. It should encourage some Member States to give higher priority to environmental protection. It must also encourage others to understand the needs of Member States with industrial concerns.

This part of the story is relatively encouraging. In fact, progress on vehicles has been breath-taking when you consider the position on the Commission's proposal for reduced emissions from large combustion plant.

Technologies are available and in use which can remove without difficulty and at acceptable costs over 90% of the sulphur from the flue gases of large plants. Our proposals call for an overall reduction by 1995 of 60% for sulphur dioxide and 40% for nitrogen oxides.

It is a modest proposal but, since it was launched three years ago, it has made little headway. In fact, the Commission has been under great pressure to water it down.

"Don't let's aim at 1995", say some Member States,"Let's aim at 2005".

"Don't let's aim at a 60% reduction in sulphur dioxide emissions", they say,"let's aim for 40%".

My answer to this pressure is a very blunt "No". I am prepared to look for different ways to find solutions to national problems. But I will not cut out the heart of the Commission's proposal.

Similar niggling difficulties exist with respect to the other proposals aimed at reducing acid emissions. There's always one or two Member States that find the so-called sacrifice too great. Meanwhile their sulphur goes up and someone else's acid comes down.

These Member States prefer short-lived economic advantage to long-lasting environmental quality. They see only industrial problems and not industrial opportunities. They

focus on national concern and turn a blind eye to the damage we are causing our friends. They want to strike a balance that is heavily tilted in favour of the selfish and the short-term. It does the Community no credit.

What we need is a small dose of political commitment. And here I make an appeal to the United Kingdom government.

- You have the Presidency of the Community's Council of Ministers until the end of the year.

- Your hands are on the levers of office. You can call meetings, fix Agendas, push for solutions.

- Make this issue your priority. Take the question of emissions of sulphur and nitrogen oxides from large combustion installations and drive for a worthwhile agreement by the end of the year. In this the Commission will give all the help possible.

A worthwhile agreement to reduce emissions from coal and oil-fired power stations is overdue. And, after the thorough discussions that have already taken place, it is attainable. I will do everything possible to secure an agreement that is good for the environment. I ask the United Kingdom government, as President of the Council of Ministers, to demonstrate its commitment.

THE IMPLICATIONS OF THE UK GOVERNMENT'S POLICY ON ACID RAIN

by
The Hon. William Waldegrave
Minister of State, Department of the Environment

As well as talking about the current British approach on Acid Rain, I shall, wearing the quite separate hat of the EEC Presidency, make some comments from that perspective. I stress that these hats are quite separate, and must be seen to be kept so, so I shall try to signal which hat I am wearing.

I must say a little bit first about Stanley Clinton Davis's very moving speech - which I have had the privilege of hearing before on several occasions. But to this audience - which without flattery (although it is always a good thing to flatter your audience) is an audience of experts, with a large number of faces familiar to me, I want to question exactly what is the purpose of that type of speech. It was full of passion, and Stanley Clinton Davis's passion on this subject is real. But I wonder whether it is appropriate to the occasion. I am engaged as an Environment Minister (as every Minister is if he tries to do his departmental job properly) in trying to increase the priority of my concerns with my colleagues in government. And I happen genuinely to believe in the priority of the concerns of my department. But I have to go back to talk to sceptics. And I wonder just how some of the lines in Stanley Clinton Davis's speech will help me with the sceptics. I have noted one or two.

To quote, "and meanwhile, while we are wasting our time in Brussels arguing about this matter, meanwhile sulphur goes up."

Well, I am not sure that one would have known from Stanley's speech that as a matter of fact European sulphur emissions have been declining. In particular, British sulphur emissions have been going down, but so have a lot of other

countries' for a variety of reasons. Some, because of great expenditure, others because of the luck of North Sea gas some because of energy conservation, some because of industrial restructering.

It is important when working on the sceptics to start from the right base. What the argument is really about is how much, in addition, are we going to spend to speed up the decline in emission levels. Stanley quite rightly (and I was grateful to him for this) made the point that Britain was not isolated on this issue, and that there are other countries which face very severe problems with the large combustion plant directive. In some cases, this is because the countries want to increase their sulphur emissions. I stress that it is important to get the base starting point of the argument right.

Another fine phrase was, "the trees are dying in the acid deluge". Well, as I think Walter Marshall would tell you, you can actually grow spruce in a surprisingly acidic atmosphere. Most of the people in Scandinavia, where I have spent a large amount of time in the last couple of years, told me (as they did in Germany) that they now know that it is not just the acidic deluge that is killing trees; it is something rather more complicated than that. The critical components of the multifarious stresses which are killing trees so dissastrously in Germany include <u>probably</u> background acidity, but this point is exceedingly complicated and it is not certain. It is no good denying this to sceptical colleagues, because then all you lay yourself open to is a majesterial rebuke from a scientist who has always, with sceptical colleages, more weight than politicians like Stanley or me: I would be left foundering, sunk.

One other point that I thought was just a little unfair, in the balance of things, was Stanley's remark that, "politicians think of nothing but the short term". I do not believe that that is quite right. For instance, I think that now there is a real chance (and I shall come back to this) that all of us in Europe can agree that all new plant should be, in shorthand, "acid free". (Even with FGD, it is not completely acid free, but low acid.) Thus, I think we are in sight of a situation where new plant built in Europe for electricity generation and other purposes will be acid free. Now, that is a major

breakthrough, for which the Commission must have a great deal of credit. It does at least mean that in the long term - and the long term is not very long in this connection, about 25 years - we are talking about a term to the problem. This is unlike the carbon dioxide, greenhouse gases problem. I see no term to that problem, indeed I see increasing danger and difficulty there. But with "acid rain" there is light at the end of the tunnel and what we are talking about now is how much to spend on existing plant, some of it heavily depreciated already, some of it coming to the end of its life, some of it new - how much to spend on speeding up that trend, and how to share out reasonably fairly the effort involved.

Perhaps in front of an audience of experts it is not fair to debate with Stanley, and if he thinks that I have been unfair I hope that he will come back with comment during questions since the meeting is not structured as a debate. But I wanted to make these comments because it is sometimes surprising to the believers just how difficult it is to convince the unbelievers. I had an ancester who was a millenarianist Bishop of Carlisle who really believed that there was very little purpose in any matter to do with this world, that the job was to prepare for the next and that those people who were trying to produce improvements in this world were really rather a bore because they were distracting attention from the other world, which was much more important and which was going to come on a certain date which he had derived from the Book of Revelations. I do not believe that we want to get into that sort of world. We are dealing with hard-faced men who want their money to be spent on something else, and they have to be persuaded, and that, it seems to me, is what our job is.

Last week the government announced two things, both equally important. As a matter of fact, I think that the announcement that had had less attention is even more important than the one which has received more attention. I think it is <u>more</u> important that the government has announced, with the CEGB, that future fossil-fuelled power stations will be fitted with whatever IAPI says is the best practicable acid free technology - probably FGD now, but it might be something better is a few years' time. We have been promised pressurised fluidised beds although always in

10 years' time! That, of course, will be a marvellous technology which is not wasteful of energy, whereas FGD is a wasteful system. The commitment to new plant being acid free is, I think, very important. I think it means, and here I stop for a moment to put my Presidency hat on, that there is a chance although by no means a certainty, of reasonably early agreement on at least part of the large combustion plant directive. As I have noted, there are some countries who want to build large power stations that would increase their output of sulphur by means of what we would now say would be out of date technology. But I think it would be something of an achievement for Europe least to come to some quick agreement on new plants because, as I have said, that would put a term, an end date, on the problem.

Secondly, we announced of course (and Lord Marshall will talk more about this) that, subject to financial arrangements, planning and engineering and scientific studies, scrubbers would be fitted to 6,000 MW of power station generating capacity, starting with the new extension to Drax. Walter Marshall may be able to tell us which other power stations he had in mind. This, of course, is not enough for those who would like us to go very much further. But I do beg those of you who have not had the privileged of discussing this matter with Ministers whose immediate statutory responsibility is not to the environment, to consider what a revolution this announcement made jointly by the CEGB and the British Government was.

Stanley quite justifiably made the point that he was going to push us further. But I think that if, two years ago, someone had declared that during my own time in the Department of the Environment we would be committed to FGD, I would have considered that pretty optimistic. But it is done, and it is an important commitment.

Now, let us go a little bit into where that will put Britain. I hate all these league tables, myself, because they can be done in so many different ways. But the commitment made by the UK government will mean that, probably by the mid 1990s the cut from peak emissions (1970 for the UK) would be about 50%,or perhaps a bit more. Incidently, if one is playing the league table game, this means that on the basis of 1970 emissions we will have cut, in percentage terms,

about twice as much as France and three times as much as Italy.

Those who do not have to go out and persuade sceptics sometimes forget that 1970 appears a much more sensible base date to a reasonably unbiased Brit. Why should countries be allowed to increase their sulphur output between 1970 and 1980, sign up for the 30% Club, and still produce more sulphur in 1993 than they were in 1970? It seems pretty fishy. Just prima facie, that is quite a difficult argument to explain to somebody - why some countries should be allowed to have a higher peak at the end of the 30% Club than their previous highest peak, whereas Britain would have a very dramatically lower peak. There are some counter-arguments to use, but pretty feeble ones.

So, by the mid-1990s, we shall be in a reasonably respectable position and I look forward to hearing what Walter will be saying, as the Head of the utility, about that position. All these positions are subject to one of the most magical and mysterious of all arts, namely energy forecasting. The sort of quasi civil service job I did in the Cabinet Office in the mid 1970s was to do with energy forecasts and I would not like to be reminded of whatever it was we said we were forecasting at that time as it would have been wrong and energy forecasts published now - even though they are sensibly published in wide ranges - will be wrong too. It is true for Britain and for all those countries which signed up for any sort of target that the targets in emissions reductions are dependent upon reasonable predictions on energy and electricity usage. But nevertheless, I believe that on the present programme and by the mid 1990s, Britain will be in a reasonably respectable position.

But, to return to uncertainties. I believe that the reason we were right to undertake this expenditure for the following reasons. On the acidification of ground water story, the remaining uncertainties are not fundamentally important to the outcome. There are many uncertainties: I have been travelling around the research station in this country during the passed couple of weeks, to Pitlochrie, the ITE and the Freshwater Biological Association and there are plenty of things that we still do not know about the exact soil chemistry in particular, and about the mechanics of subject,

for example variables about such as frozen ground. But few people doubt that the addition of acid to badly buffered soil produces changes in the water, including in particular the leaching of aluminium and some other metal which damage fish. The most reasonable explanation of why many lakes and rivers in Norway and Sweden have been denuded of fish is that this has been caused by acid deposition in various forms - dry, wet. and in mist and so forth.

There is still a far more radical uncertainty about the tree damage causes. You will probably talk about that later in the day. No politician should be so silly as to say that acid rain is killing trees, because he will be shot to pieces by scientists and he will be prevented from making any progress at all with his colleagues. If we do take action using the tree argument, it can only be on the grounds of prudence and risk numbers attached to probabilities of different causes. Such an exercise has to be carried out in a rather cool and careful way.

We have to remember that there are two audiences on this. When we announced our programme last week, the Daily Express said, "Electricity prices in Britain will go up 1.5% to cover the costs of cutting acid rain, it was announced yesterday. Ministers are bracing themselves for a flood of complaints." Again, I think we have to be careful in the rhetoric about prices. A one and a half per cent increase is not all that high, as an addition. But, imagine the position of the managing director of a large plant on Tyneside, for whom electricity may form 40% of his principle costs. He looks at France, where the electricity costs are very much lower, and he will regard any additional increase in electricity prices as the final thing which will force him to close that plant and move it to Lyon.

Britain is not yet very competitive it comparative electricity cost terms. I will argue that a one and half per cent additional costs is perfectly acceptable, and that is the veiw that the British government is taking. But the cost should not be dismissed as if it were negligible. The cost of complying fully with the terms of the large combustion plant directive would be far more dramatic, and I am not even certain that a 30% drop in NOx could be guaranteed by the target date in the draft directive.

Reference to the United States experience provides an example of the difficulty of reducing NOx, unless restrictions on the use of vehicles are imposed. In Britain, partly because of the relatively small increase in the number of motor vehicles, we have held our NOx levels fairly steady while in the Federal Republic of Germany, for example, there have been fairly dramatic increases in NOx levels since 1970. While low NOx burners in power stations provide a much cheaper option, the problem of controlling total NOx emissions is a little bit more complicated than is widely credited.

Putting my Presidency hat on again, I believe that Stanley Clinton Davis was right to say that unless we can get some steady movement on the large combustion plant directive there will be considerable frustration in various countries. This is perhaps an unfair comment, but I thought there was something of a contradiction in the structure of his speech. For example, he personally, to his great credit, brokered a major step forward on the vehicle emissions directive which was much less than the Germans wanted and is clearly less than the Danes want. The Danes are holding out against the directive. But it represents a very major step forward and I think he was right to say that Europe took a responsible view in seeking a compromise. But, when it came to the large combustion plant directive, the tone of voice was a bit different. Yet I believe that it is absolutely certain that there will have to be some compromise if there is to be any progress. I think the Presidency's job is to follow on from where the last Presidency - the very skilful Presidency of Peter Vinsemius, whom we will miss in the Environment Council - left off. The last Presidency tried to put forward some ideas of a different structure, which would of course be less satisfactory than what the maximalists want, but in order to maintain the momentum which is so important. I certainly regard my Presidency job as seeking to broker some way forward.

Then, returning to the point about persuasion of colleagues to commit valuable resources and so forth, I believe that I am much more likely to win resources by saying that there has been some movement on both sides. This is how politics work. If I bluntly say, "There is a demand that we are

compelled to accede to", I think I will be bluntly told, "Good afternoon!".
So, I strongly believe that we will have to try to broker some way forward. I have already said that I believe one important element of the way forward is agreement on new plant - this is a major item, and a major commitment for future. It puts a term on the problem. I think we should have another look at the Dutch proposals and see whether there is not something useful there. They contain great difficulties for the British delegation but the Presidency has to distance itself a bit in the negotiations. That, at any rate, is what I regard my job as being. I remain pessimistic, I think, that the situation will be easy even on the compromise proposals. One of the great difficulties (and Stanley hinted very delicately at this) in being one of the countries with great problems with any proposal is that the smaller countries can keep their heads down out of the firing line. But when compromise proposals are produced, you find that other difficulties emerge rather sharply as countries begin to have to concentrate on their negotiating briefs. So, this is a difficult issue, it is one on which we must make progress, it is one on which I personally believe useful progress can be made, but it will only be made on a basis of compromise and of a rather cool appreciation of where the uncertainties are and where the real consensus is. Ultimately, I think you do not persuade the Member States simply by the strength of your anxieties.

This is a very timely conference, at the beginning of our Presidency, and it is right to focus on this problem. I am delighted that the British government has committed the CEGB and your money (those of you who are UK consumers of electricity) to expenditure in this area. I am delighted that the new plant position is as it is. I do not know whether this is the end of the story, but I know that it is a very major step forward and we would be failing, I think, just in terms of political skills and techniques if we did not enable our people to realise that there have been steps forward, some of which can probably now be embodied in reasonable compromise European legislation.

ACID RAIN : THE POLITICAL CHALLENGE AN INDUSTRY VIEWPOINT

by
Lord Marshall of Goring
Chairman, Central Electricity Generating Board

The title of this conference links acid rain and politics. That link is reinforced by the choice of speakers today and the background paper which the organisers provided in advance. That background paper actually treats the whole subject as a political matter. My own viewpoint is quite different. I view the phenomenon of acid rain overwhelmingly as a matter for scientific assessment and technical judgement. I accept that my viewpoint might not be valid in other countries or even for other industries in the UK but I am grateful for this opportunity to set out for you why the approach of the CEGB is necessarily different from that of most people in this audience today.

May I first remind you that the CEGB is a large nationalised industry whose actions are determined by the Parliamentary statutes that set up the electricity industry in this country. Those statutes place upon the CEGB the principal duty

> "to provide an efficient, co-ordinated and economic supply of electricity in England and Wales".

But that is not the only responsibility placed upon us by Parliament. We have also been given, by Parliament, a clear responsibility for the environment and the words used in the statutes are, and I quote,

> "...in considering any proposals relating to the functions of the Generating Board ...the Board shall ... take into account any effect which the proposals would have on the natural beauty of the countryside or on any ...flora, fauna, features, buildings or objects."

This statute does not limit our responsibility to effects

within the UK although I rather doubt if the people who originally drafted the Bill had had transboundary pollution in mind. Be that as it may, we in the CEGB interpret that statute as meaning that we have a responsibility for the environment which we must reconcile with our principal responsibility of providing electricity. Of course Parliament does not tell us how to achieve a correct balance between our economic and environmental responsibilities; that is what the Board of the CEGB is expected to do. In one sense, therefore, I can argue that the political challenge of dealing with acid rain or any other environmental problem caused by electricity production was met many years ago in the UK when Parliament wrote the relevant Acts which apply to the electricity industry.

From a philosophical point of view, I must tell you that I think that is a wise way to set about the problem. It makes it clear that the first responsibility for making a judgement between economic and environmental factors lies with the Board itself. The regulators appointed by the Government who audit what we do and who monitor what we do, can impose rules upon us if they do not consider that we do our job properly. If both we and the regulators fail to win public confidence then Government and Parliament should step in to correct whatever is wrong.

Of course private industry is not controlled by individual Acts of Parliament and the arguments do not apply with the same force to them. However, I am proud to claim that in the UK there is a long tradition of private companies having a deep concern with the environment. Neither do I want to press my argument to an absurd level. Clearly we must be very responsive to public opinion and the advice we get from Select Committees and the Royal Commission on Environmental Pollution. I simply wish to reiterate the point that we consider we have a duty <u>ourselves</u> to balance economic and environmental factors. It is not our duty to give sole attention to the economics of electricity production.

Ever since I became Chairman of the CEGB, about four years ago, I have insisted that the Board could only carry out its statutory duty to have concern for the environment if we had a proper basis of scientific understanding of the

environmental problem. My background and training has been in the nuclear business and there we know a great deal about the environmental risks of nuclear power and the effects of nuclear radiation. I was concerned to discover that we knew very much less about the environmental effects of generating electricity from fossil fuels and I was worried about all the early arguments concerning the effects of acid rain. We were unable to accept those early arguments that sulphur emissions were killing trees and forests in Scandinavia. We were even more sceptical about the arguments that sulphur emissions were killing trees in the Black Forest. We thought it very likely that the troubles in the Black Forest were due to something else. For that reason we decided to resist political pressure to take action because of alleged forest damage.

We were much more cautious about the problems of surface water acidification and fishery damage in Scandinavia. We distrusted the original very simple arguments. We knew that fish could live in water of low PH. The problem, we thought, had to be more complex. We thought it likely that the problem was associated with the state of the soil, not just the deposition from the atmosphere, and we knew that the state of the soil could be affected by many land use factors, particularly afforestation and the choice of coniferous rather than deciduous trees for those forests. Given those scientific uncertainties, we made a second judgement, namely that we were not willing to invest huge sums on desulphurisation equipment on the scientific evidence that we had at that time. We were, however, concerned about the lack of proper scientific understanding of these matters and we decided that in addition to our own research programme, we would make available #5M for a programme of additional research to be directed and managed by our own Royal Society, the Swedish Royal Academy of Science and the Norwegian Academy of Science and Letters. British Coal joined with us in sponsoring this work. We posed to them the simple question:

> "What changes would be brought about in water chemistry and in fishery status in Norway and Sweden by given levels of reduction of man-made sulphur deposition?".

We asked them to report back to us as quickly as possible. We made it absolutely clear that, from our point of view, the money was in a blind trust and we would not attempt to direct the research ourselves. We insisted that the results of that research be published in the open literature. We also made it clear that we would welcome resolution of these scientific issues whether it brought comfort or dismay to the electricity consumer in this country. We gave a clear undertaking that our policy would be guided by the results of the scientific research. To their credit, the Royal Society and the two Scandinavian Academies believed us, accepted that the scientific case needed to be proved, and accepted the challenge we had given them. However, the CEGB was very much criticised at the time. Some people argued that we were doing research simply to delay action, some people argued that the scientific facts were already known and some even argued that it did not matter what the scientific facts were. But we actually meant exactly what we said and we have followed the progress of scientific thinking and the evolution of understanding which has taken place in the last few years very carefully indeed.

Although the Royal Society's research programme is in its relatively early stages, we feel we have already learned a great deal from it. We have benefitted enormously by being able to watch the Royal Society and the Scandinavian Academies deciding for themselves which existing research was valid, which needed confirmation, and which needed fresh ideas. The project has necessarily had to review all the existing research programmes in Scandinavia, many of them involving research which is not yet published in the scientific literature. Therefore, partly as a result of this research programme itself, but even more so of recent research which the Scandinavians have themselves done, we now feel that we have a solid and sound scientific basis for linking acid emissions, acid depositions and fishery status. Of course, a great deal more needs to be done but the broad basis for a proper scientific understanding does now, I believe, exist. According to our present understanding, many of the reservations the CEGB has had, turn out to be both valid and to have real content. For example, the contribution made by the United Kingdom to deposition in Norway and Sweden is, we believe, much less than was previously argued. The contribution from over the Atlantic

is larger than was previously thought. It is not simply acid rain that kills fish; the soil does have a vital role to play. We now know that it takes acid soil as well as acid rain to produce acid lakes; it is not the acidity itself that is toxic to fish but the aluminium which is leached out of the soil in these circumstances. Forestry, especially coniferous forestry, makes the soil more acid and Norway spruce in particular seems to have a great ability to scavenge dry sulphur dioxide from the atmosphere.

But despite all this, acid deposition, and in particular sulphur deposition, plays a very important role. An extremely important fact, now emerging, is that sulphur has been building up in the soil for decades or even centuries. The new research is also showing that while acid deposition is increasing, the size of the store increases. In some places at present, it is equivalent to the entire deposition of several decades. When deposition decreases, the store can start to leach out. That process must already have started. What we have to face now, is that the acidity may take decades to leach out completely and all this time it may be carrying toxic aluminium into surface water.

In the last two or three years there has been growing evidence, from the sediments of acidified lakes, that the process of acidification has been going on for a century or more. Because of the condition of the soil, it won't be reversed overnight. Many things will need to be done to solve this environmental problem. It is not just a matter of decreasing acid emissions, but decreasing emissions on some appropriate timescale must surely be the proper policy.

This alone will not be enough to restore the quality of water necessary for healthy and reproducing fisheries. As recent experiments in Norway have shown, even if acid deposition is turned off overnight it will take a very long time indeed for the reservoirs of acid sulphur in the soil to leach out. Many people doubt whether the water can be restored in a reasonable time unless measures are taken to improve the quality of the soil. This can be done - we are demonstrating it at Loch Fleet in Scotland. It's not cheap, but it's a lot cheaper than flue gas desulphurisation, and a great deal quicker. And it copes with all forms of soil acidification, not just acid deposition.

The CEGB had always promised that we would act responsibly once we were satisfied about the scientific arguments. Therefore, given this fresh scientific understanding, we made a recommendation to the Government that we should retrofit enough of our power stations to ensure that taking one year with another our sulphur emissions continue to decrease steadily throughout the remainder of this century. After the turn of the century, our existing stations will start to be replaced with new plant which does not emit sulphur. Therefore, at that time our sulphur emissions will start to fall dramaticially. As you all know, the Government has accepted our recommendations and this action programme is now in hand. They have, of course, made the proviso that our present scientific understanding must be confirmed by the Royal Society and the two Scandinavian academies when they give a first report to us next year. However, as from today, we are assuming that that confirmation will be given.

As a result, the sulphur emissions from the UK historically and in the future will follow the attached graph which also shows CEGB emissions alone. We believe that is a balanced and scientifically valid reaction to the problem. If anyone disagrees, we will listen carefully to sound scientific arguments and act accordingly.

May I now tell you about the thinking which will guide our actions in the future. We have made proposals which, in our judgement, balance our economic and environmental responsibilities. We believe we are taking action on broadly the same timescale which is needed to correct problems in Scandinavia. Now we understand the problem, we can also see that it will not be solved quickly and if it cannot be solved quickly, then a crash programme by ourselves is not a balanced response. Obviously, we will maintain a close interest in this entire matter. We will continue to be guided by the scientific facts and if evidence does emerge to suggest that we should be doing something different, then we will look at the whole matter again.

We take the same scientific approach to other matters also. We were concerned about NOx, hydrocarbons and ozone before it became fashionable to be concerned about them.

We have done important experiments on the reduction of NOx in our power stations and we are moving to the position where we can implement that, if we judge that is the appropriate thing to do. At the present point in time, we are sympathetic to the argument that ozone has an important role to play in the damage to forests, but we do not regard that as proven and because of the complicated chemistry which takes place in the atmosphere, we do not know at the moment whether reducing NOx emissions would make this problem better or worse.

I mentioned to you earlier that we did not accept that our sulphur emissions were directly affecting forests, but that does not mean that we are complacent about this phenomenon. We notice the possibility that acid mist rather than acid rain may be a culprit and we are suspending judgement on that matter. We are anxious for all these scientific uncertainties to be resolved and we have therefore asked the National Environmental Research Council to do research on the effects of ozone and nitrogen oxides on trees and plants.

Given all this background, I hope you will see that the kind of arguments advanced in the background paper have very little direct relevance to the CEGB - they may very well be vitally important in other countries and for other organisations, I cannot speak on that - but we in the CEGB are anxious to listen to everyone's opinion, we are happy to take advice, we are grateful for the interest which the Select Committees take in our affairs, but what we do is overwhelmingly influenced by our own assessment of the scientific facts. I believe that was the original intention of Parliament in giving us our statutes. I can assure you that that is going to remain our point of view in the future as much as it has been in the past.

THE VIEW OF THE UK HOUSE OF COMMONS ENVIRONMENT COMMITTEE

by
Sir Hugh Rossi, MP
Chairman, House of Commons Environment Committee

Ladies and Gentlemen, first of all I would like to congratulate the NSCA for its superb timing in arranging this Conference; because once again acid rain is in the news, and scarcely a day has passed within the last fortnight in which there hasn't been some comment or article in one journal or another. My belief is that this is not unconnected with recent events abroad.

Early last week I happened to be in Stockholm representing, with others, our Parliament at the Nordic Councils International Conference on transboundary air pollution. Now this was a day or so before our Prime Minister was expected in Norway, and we found that expectations in Stockholm were running extremely high; rumours abounded that at last a declaration was going to be made that the United Kingdom was about to enter the 30% Club. In the event this was not the case, to the inevitable disappointment of the Scandinavian countries. But the intention to retrofit three power stations, under discussion this morning, is certainly a tremendous advance upon the United Kingdom's previous position.

As, Chairman, you may remember, my Committee recommended in our report two years ago that the United Kingdom should join the 30% Club; and all of you know that this entails a commitment to reduce sulphurous emissions by 30% between the years 1980 and 1993. At the time we wrote our report, we were told that emissions of sulphur dioxide were down 37% since 1970, of which about 13% had occurred since 1980. So in three and a half years we had achieved 13% of the 30% target, owing to a variety of factors - natural gas being possibly one of the most

significant. This meant that in 1984 we had another 17% reduction to achieve over another 13 years, and the Committee came to the conclusion, bearing in mind the possible cost of taking measures to achieve this end, that it was something that the United Kingdom could and should undertake. We were told that the increased cost of electricity would be something in the order of less than 1% per annum; and we were convinced that we should do this, not only because of evidence that we had seen in Scandinavia and our belief as Parliamentarians in the need to remain good neighbours with other countries, but also because we saw that similar effects were beginning to be felt in the United Kingdom - in Galloway, Scotland, particularly.

Now I assume that this morning there has been a great deal of discussion as to the various possible contentious effects of sulphur dioxide emissions upon various parts and aspects of our environment. My Committee considered scientific evidence of not only what was happening in this country, but also what was happening abroad. And in an ascending scale of damage attributable to sulphur emissions, we came to these conclusions.

First of all, in so far as trees and forests were concerned, sulphur dioxide was part of what was descibed to us by a Scandinavian scientist as a poisonous cocktail, which so weakened tree structure as to make trees easy prey and victims to natural enemies. There was nothing conclusive to show that sulphur dioxide alone was the culprit; indeed earlier speculations as to that were increasingly doubted and ozone was becoming the front runner. Ozone itself, of course, is the product of burning fossilised fuel in other forms and in other ways than by industry for the production of energy.

Next we looked at the problems concerning water life, particularly in Scandinavia, and we came to the conclusion that there was a direct connection between emissions of sulphur - the production of what is popularly known as acid rain - and the effect upon water systems and loss of fish life.

We also found that there was a connection between these

emissions and the damage suffered by historic buildings in this country, particularly those built from sandstone and limestone because of the chemical reactions that took place between the stone and the sulphur deposited upon it. This was something that we came across almost by accident because when we were taking our evidence in the United Kingdom nothing was said to us about this by anybody. Then we beat a path, which I was glad to hear was being followed by Lord Marshall, to Cologne Cathedral and there we were told about it by the curator and architect and shown the chemical reaction that was taking place between the stonework and sulphur depositions. We asked whether the same thing was happening in the United Kingdom because this was the first knowledge we had of this particular phenomenon as a layman Committee. They told us to go and look at Lincoln Cathedral.

On our return to the United Kingdom we proceeded to take evidence from the PSA, from the BRE, and from the CEGB but nobody could really give us any help at all. It was quite clear that very little research, if any, had been taking place on this particular matter. The CEGB had just started looking, some two years previously, at the possibility of effects upon building materials. The BRE had looked at the effect on stonework some 20 years before and carried out some research on metals, but there had been nothing further. The PSA had no centrally held information thus we had no evidence in the United Kingdom, worth studying, compared with what we had been told overseas. So we decided to write around to the architects and curators of various historic buildings and cathedrals; and the evidence absolutely began to pour in. It is not just a question, as has been suggested, that perhaps the existing damage to stonework is historic and happened hundreds of years ago. We were given photographs, some of which we published in our report, of damage to Lincoln Cathedral in 1910 and in 1984. It is quite remarkable how gargoyles and other architectural features, which remained distinct from the Middle Ages until the turn of this century, have dissolved and corroded in a relatively very short period of time. This cannot be attributed to the weathering of centuries. There is a direct nexus between the industrial revolution and depositions which have not ceased, from one source of emission or another. I think it is now quite accepted that there is a connection between the

corrosion of buildings and acidic depositions upon them.

So these were the matters that we decided to put in our report and which were behind our recommendations that immediate action was required to extend the whole field of research, and also air monitoring. Very little air monitoring was being done at all. The quality of the air was not known. And as a result, I am happy to say that the government accepted all of our recommendations regarding research. However, it was very cautious concerning the joining of the 30% Club.

What the government answer said (and I will read it to you very quickly) was this:

"Building on the 40% reduction in SO2 emissions achieved since 1970, the government aims to achieve a further reduction of 30% from the 1980 levels of SO2 emissions by the end of the 1990s, and a similar reduction in levels of NOx emissions. It also intends to support stricter emission standards for petrol engined cars achievable by the development of lean burn engines. It does not believe that the very substantial expenditure running into hundreds of millions of pounds which would be required to install flue gas desulphurisation plant at existing power stations can be justified while scientific knowledge is developing and the environmental benefits remain uncertain. It will however continue to encourage the development of new technologies which can provide more cost-effective solutions."

The importance of that paragraph to me, was that first of all the government had accepted the principle that there was a need to reduce emissions. What it was arguing about basically was the timescale in which the reduction ought to be achieved, not by 1993, but by the end of the 1990s, and furthermore that immediate cost was not justified while scientific knowledge was developing and environmental benefits remained uncertain.

The Committee decided, having had that reply from Government and a debate in the House of Commons, not to leave the matter there and simply turn our attention to other issues. We have indeed turned our attention to other matters, and in the spring we came out with a report on

radioactive waste management which also attracted a certain amount of attention.

But we decided to return to Acid Rain a year later, partly to allow ministers and officials to give us an update on what was happening; they came before us in the spring and we published the evidence as to what they had come to say to us, in a second report which was printed on the 27 November 1985.

First, the government made it quite clear that it had fully implemented its promise to undertake necessary research. Dr. Holdgate, the Chief Scientific Advisor to the Department of the Environment (who will be here this afternoon, I am glad to see) said in reply to a question put to him,

"I am not in a position to tell you in any real detail this afternoon, but I can assure the Committee that there is no area of research which you identified in your report that is not being carried forward and we have not been inhibited by lack of funds from setting up programmes in any of the areas you specified as necessary."

We regarded that as an extremely gratifying reply, showing positive thinking on the part of the government, and an anxiety at least to satisfy itself where the truth lay in these matters, having received a degree of conflicting scientific advice from differing sources. On the question of joining the 30% Club, the government reply was a little more ambivalent. The Minister at the Department of Energy in charge of these matters, Mr. Goodlad, said that the cost of joining the 30% Club if borne by the CEGB depended upon the assumptions made about the sulphur dioxide emissions trend up to 1993. The emissions in 1984 were estimated at 3.52 million tonnes, about 25% below the 1980 level. Now, that leaves us 5% short, from November 1985, of achieving the 30% target.

William Waldegrave did intervene to say that 1984 was an exceptional year because of the miners' strike and one may well have to make adjustments. But clearly, there is a downward graph naturally happening within our economy as far as sulphur dioxide emissions are concerned. And Alastair Goodlad went on to say that, assuming no further change in

emissions levels (that is, given they remain at the 1985 level) the capital cost of achieving a 30% reduction from the 1980 level would be about 300 million, equivalent to about 1% on electricity prices. That would be the cost of installing FGD at two large power stations to reduce CEGB emissions by .2 million tonnes of sulphur. So we have a ministerial statement that the 30% reduction could be achieved by the installation at two large power stations.

I find myself in a certain amount of difficulty in trying to assess where we are now, because as you know, the Secretary of State for the Environment issued his press statement that it is now the intention to retrofit three power stations. The only difference is that this is not going to happen until between the years 1988 and 1997. I can only imagine, and we have not yet been told this, that it is not technically feasible, or logistically possible, to carry out the necessary work on the power stations before 1988. But nevertheless, the commitment is clearly there, and does indicate a very very sharp change in policy. It may well be that the results now becoming evident from the domestic research that is now taking place, and which was not taking place before, is leading government inextricably towards the conclusions that the committee felt it was able to reach in 1984 having studied the evidence of scientists abroad. But nevertheless, if this is happening it is very welcome indeed.

To bring the matter up to date, just before I went to Stockholm I did ask the Department to give me the latest position as regards the government's thinking. I received a note which said,

"The UK government accepts that there is now widespread agreement that acid deposition is a major cause of acidification of freshwater systems in areas such as Galloway in Scotland, and southern Scandinavia which are sensitive because of their geology."

That is an important acceptance of principle which up to now has really been denied or side-stepped. There was also an acknowledgement that our sulphur dioxide emissions have fallen by more than 20% on the 1980 figure - a little less than Alastair Goodlad had told us. He spoke of 25% last

year, now we are speaking of 20%. Perhaps the decreased drop in emissions is because of the hiccup caused by the miners' strike. But nevertheless, on the latest figures given me only last week, we are within 10% of the target that membership of the 30% Club requires of us by 1993. And of course we know what the cost of achieving this will be - we have heard of it from the government statements.

Giving you this history as it is seen by my Committee through the eyes of Parliamentarians, I think that it is important and gratifying that we have now reached this situation where the government has accepted the case in principle, is determined to take remedies, is prepared to put the money in, is carrying out the necessary research and is merely asking for a little more time. I think that stems possibly from the British character. I don't think that we like very much to make a promise, make a commitment, unless not only do we intend to implement it, but also can see our way clearly to being able to implement it. We need two things: first, honest intention, and second, the ability to see the way to discharge our obligation. Maybe others are prepared to sign on the dotted line on the basis of honest intention and when the time runs out say,

"Well chums, we have done our best but we haven't quite made it, give us another couple of years."

That's not our way, difficult though it is for other people to understand, but perhaps it is the most honest way. Nevertheless progress is being made, and we are gratified that this is being done.

ACID RAIN IN THE UNITED STATES

by
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Unlike the United Kingdom, the United States is not renowned for its footpaths: the countryside is structured around access roads for cars and farm machinery, and footpaths are few and far between. When one can find a footpath, it is often in a National Park, designed to turn nature into a showcase, or it is on a truly gargantuan scale, like the Appalachian Trail, a footpath that winds its way for more than 2000 miles from Mount Katahdin in central Maine to Springer Mountain in Northern Georgia. The Trail, which is maintained entirely by volunteer groups, runs mostly through forests along the crests of the Appalachian Mountains which stretch along the East Coast of the United States at modest elevations ranging up to 6500 ft, in some ways comparable to the mountains and forests of central Europe. Countless natural lakes dot the landscape of this mountain range.

Some people walk the entire length of the Appalachian Trail; some even do so regularly. You would need to do this to truly appreciate the extent and nature of forests in the Eastern United States, a vast, at present relatively little used resource, about as different from forests in continental Europe as it is possible to be: while there is little virgin growth left, most of the trees are there because they grow naturally. As anybody who has tried to keep a Vermont forest out of his meadow can atest, it takes but a few years for trees to invade any open spaces. Some of this huge forest area is publicly owned, some of it is designated as wilderness under American law, making access extremely restricted (A few years ago, researchers wanted to study the acidity of mountain lakes in the Adirondacks of New York State and promptly ran afoul of the wilderness designation which forbids entry with mechanical devices for any reason, even for research which might possibly protect the forests

from grievous damage). Most of the forests in the Appalachians are privately owned.

Contrary to popular perception, the large forested areas of the United States are to be found in the East and not in the West. The state of Georgia alone has almost as much forest area as the states of Oregon and Washington combined. While just under 15% of the state of California is covered by forest, almost 79% of Maine is. The 20 Eastern states in which the Appalachian Mountains lie have an average of 52.29% of their land under forest (the national average is 20.29%). The total forest area of these 20 states is 295,000 square miles (an area only very slightly smaller than that of France and the Federal Republic of Germany combined; the land area of the United Kingdom is 94,500 square miles).

Not nearly as much of this forest as one might expect is actively managed, and the current rate of extraction is far below the potential yield. In the Eastern United States, large commercial forests are to be found mainly at lower elevations in the states of Maine and Georgia, in the foothills and plains on the fringes of the Appalachians.

In addition to their forests, the Appalachians contain many resources, including large desposits of coal in the Central and Western portions, unfortunately most of it containing large amounts of sulphur, even as much as 3%. This coal is being used to produce electricity - and causes very large emissions of sulphur dioxide to the atmosphere. These emissions spread over the entire region defined by the Appalachian mountains and beyond. With Appalachian forests, lakes and coal all potentially involved, to date acid rain - that is the transport of a variety of air pollutants over long distances - in North America has appeared mainly as an Appalachian drama.

You may notice that Canada does not figure in this scenario: it lies to the North of the northern end of the Appalachians; its forests are in many ways different both in terms of elevation and species, and even its many lakes - Canada has more lakes than any other country in the world - are distinctly different from those in the Appalachinas. For many years, the Canadians were convinced that air pollution was not their problem and consequently permitted themselves

the symbolic luxury of operating what is widely considered to be the largest single source of sulphur emissions to the atmosphere in the world, a smelter owned by Inco in Sudbury Ontario.

Air pollution has a nasty way of spreading; no matter where you emit pollutants, weather permitting they have the potential to travel very far. It has taken us a remarkably long time to recognise this fairly elementary fact, long obscured by some much more dramatic cases of local and regional air pollution: it is consequently not surprising that the countries with smog problems turn out to have been the early leaders in air pollution control: the United Kingdom, the United States, Japan, the Netherlands and the Federal Republic of Germany. It is fruitless to argue who was first, but my guess is that this is the approximate order in which action was taken. Despite all the high rhetoric, and sometimes even despite the letter of the law, the solutions which were applied tended to focus on the local and regional problems and involved a certain degree of transfer of pollutants to longer distances. The United States provides a textbook example.

The Clean Air Act, first passed in 1963 and since amended several times, most importantly in 1970 and 1977, establishes a complex, comprehensive network of provisions designed to control and reduce air pollution. Its primary focus is clearly urban air pollution, but it also contains significant provisions designed to ensure that there is no deterioration in areas with better air quality. The act mandates "an action-forcing regulatory strategy directed toward achieving pollutant-specific national ambient air quality standards by specific dates". The central tool for implementation is the state implementation plan (SIP) which each state must establish under the supervision of the federal Environmental Protection Agency (EPA) and then implement with its own means. The framework for these plans is established through the national ambient air quality standards (NAAQS). For new sources there are new source performance standards (NSPS).

The law provides that no SIP shall be approved which does not contain adequate provisions to prohibit any stationary source within one state from emitting air pollutants in

amounts which will prevent attainment or maintenance by any other state of national ambient air quality standards or interfere with certain other measures required of other states under the law. The difficulty with this seemingly clear and far-reaching provision lies with the evidentiary requirements for making a negative finding: in practice monitoring data on actual emissions will be hard to obtain, so the evidence must be obtained by computer modelling; the art of modelling is however such that the EPA will not accept as reliable evidence models which go beyond a 50 mile radius from the source, in other words all long distance effects have been excluded in practice, leaving an incentive for the redistribution of pollution over larger distances.

The Clean Air Act Amendments of 1970 and 1977 did indeed lead to significant improvements in urban air quality, although the frequently stringent NAAQS have not been met in several regions and are unlikely to be met in some. Beyond this, they have been the cause of a steady reduction in total emissions of certain key pollutants, sulphur dioxide in particular. Compared with most European countries, it was long possible to speak of the United States as a leader in air pollution control.

In many respects, these very successes have made it particularly difficult for the United States to confront its failures in dealing with the phenomena of long range air pollution: the successes were achieved through substantial efforts on the part of all parties concerned, and the focus on the largely health-based NAAQS tended to divert attention from areas where the relative change in air pollution was substantial - because they had known little or no pollution before - but which continued to meet all NAAQS and where the most affected goods were water and plants which were being subjected to long term exposure at low levels of pollution. As in Europe, one of the most vexing problems with "acid rain" is that evidence of damage is occurring in many areas which meet most existing standards for air quality.

It has always proven exceedingly difficult to provide incontrovertible evidence linking cause and effect in long range air pollution. On the one hand, we have clear evidence that air pollution is transported over long distances,

but even this was contested in the United States until clear proof was recently provided linking deposition in several parts of the West to emissions as much as 1000 miles away; on the other hand we have evidence of damage, first to lakes and subsequently to forests. The greatest difficulty has been linking one to another in a manner which meets traditional criteria of proof for public policy.

As in Europe, the first effects of acid rain in the United States were felt in surface waters; but even here the evidence is uneven and consequently subject to contradictory interpretation, particularly the evidence of damage to U.S. surface waters. A recent census of lakes in the Appalachian mountains shows changes on a massive scale, but changes in all directions and with hardly any discernible pattern: some lakes are more acidic, but others have actually become less so; not all lakes in the North-East are affected nor are all the most affected lakes in the North-East.

The evidence of surface water effects in Canada is much more clearcut, because Canadian lakes are in a sense more like Scandinavian ones: relatively shallow, on a granite base which offers little buffering capacity; long winters cause snow to accumulate and the stored acidity can be released in spring in a pulse, causing acid "events"; heavy summer thunderstorms can have a similar effect.

This distribution of cause and effect created a distribution of roles which reminds one of nothing so much as the relationship between Great Britain and the Scandinavian countries: the causes are concentrated in Ohio which is south-west of Eastern Canada and the effects are concentrated in the North-East, with an intervening international border. However, the relationship between Canada and the United States is much closer than that between Great Britain and its Scandinavian neighbours. Consequently, the Canadian government had the means to keep acid rain on the U.S. agenda at a time when the U.S. administration clearly was unwilling to act on this issue and U.S. domestic environmental forces and the politicians of the U.S. North-East proved unable to induce action. While acid rain was an important domestic U.S. policy issue in the late seventies, pitting the North-Eastern states against the coal mining midwestern ones - Ohio in particular - in the eighties

it has been primarily an international one, with Canada exerting unremitting pressure on the United States for action.

Over the past six years, the history of the U.S. - Canadian relationship on acid rain has not been a happy one. The U.S. government long tended to underestimate the importance of this issue to Canada. After a "Memorandum of Intent concerning Transboundary Air Pollution" was signed by the two countries in 1980, outlining a process by which action on acid rain was to be initiated, the early eighties witnessed a dramatic drawing back from this commitment on the part of the United States. This was particularly difficult for the Canadians to understand since it involved the transformation of a process which was originally designed to be scientific in character into a politically controlled one.

The last three years have been spent undoing the damage which was done. In 1985, the heads of state of the two countries each nominated personal representatives to consider the issue. These "acid rain envoys" reported back early this year, carefully setting out the history of the issue and the areas of consensus, including some clear-cut statements on the seriousness of the issue and calling for a substantial program of support for research on abatement technologies. These recommendations have been endorsed by both the President of the United States and the Canadian Prime Minister. It is possible to summarize the current situation with the observation that through intensive work on the part of the Canadians we are now back where we were in early 1980: acid rain has been recognized as a significant problem by both countries. Despite this recognition, however, many pitfalls remain as the record has been loaded with U.S. statements of marginal accuracy made at a time when reasons were being sought to avoid action but which cannot and will not be renounced for the obvious diplomatic reasons. Some benefits have, however, begun to accrue from this shift in position. Internationally, for example in the context of the Geneva Convention on Long Range Transboundary Air Pollution, the United States will probably cease to be the minimalist which it has been for the past few years, although this change in attitude is unlikely to extend to signing the Helsinki Protocol. Domestically, acid rain legislation is again beginning to show some sign of life.

Throughout the last six years, acid rain legislation has continued to be proposed in Congress but never got beyond the most preliminary stages of the legislative process. In 1986, a bill was for the first time voted out of subcommittee in the House of Representatives. In the Senate a somewhat more stringent version is still in committee. It has again become possible to speak of acid rain legislation as a politically conceivable hypothesis. I will not go into the arcana of Congressional manoeuvring involved in these bills except to note that much as in the European Community two control philosophies appear to be competing in the United States: the imposition of a stringent program of retrofitting based upon emission standards comparable to those adopted by the Federal Republic of Germany and the mandating of a certain level of reduction with a degree of flexibility in the choice of appropriate means to achieve these. As in the European Community, I would personally favour the latter approach. Ultimately of course the three key issues will continue to be how much to reduce emissions, where to reduce emissions, and how to pay for reductions.

Canada has finally moved to reduce its own acidifying emissions as well: over the past 24 months, programs have been announced at both the federal and the provincial level designed to ensure dramatic reductions in sulphur emissions from smelters, power plants and automobiles. As a consequence, Canadian pressure on the United States has gained significantly in credibility.

Less well known is a remarkable phenomenon at the state level in the United States. Over the past three years, several states have adopted acid rain legislation of their own. The reasoning behind these measures is much the same as that of Canada: by showing a willingness to adopt measures in their home jurisdictions, politicians in the states in question hope to lend additional force to their arguments with representatives from other parts of the country. Several states have entered into negotiations with the neighbouring Canadian provinces and have even signed agreements with them. The underlying attitude is that these states are not willing to wait for the federal authorities to act.

At the federal level, decisive action will still have to wait for a change in the relative strength of the various competing interests. Two factors could be critical in this regard: evidence that other regions of the country are being affected by acid rain, and evidence that serious damage is occurring to commercially significant forests. Neither has yet attained enough credibility to have an impact.

In California, acid rain has long been a matter of concern, but in this region it is caused primarily by local precipitation from automobile emissions and peculiar weather and rainfall patterns. Long range air pollution has not been an issue. More recently, however, the states along the Eastern fringe of the Rocky Mountains have begun to worry about acid rain, from urban development in the United States, and from some large smelters currently being constructed in Mexico. In the latter instance, the United States is on the receiving end of international pollution, and it is striking to note that U.S. concern has been vocal and effective: in summer 1985 an agreement for desulphurisation of the smelters was reached with Mexico. The areas most likely to be affected include some of the best known National Parks in the American South-West, viewed by many Americans with a degree of proprietary affection akin to the feelings Germans express about their forests.

Much the most disturbing evidence of damage is, however, beginning to accumulate with respect to the Eastern forests mentioned at the beginning of this presentation. In some places, there is truly dramatic forest dieback - readily comparable in appearance to what has been observed in continental Europe. Until recently, most researchers still had reasonable explanations for most of these phenomena: primarily an assortment of bugs and weather effects. Over the past eighteen months, however, the signs are accumulating that something larger is happening: in North Carolina on Mount Mitchell, the highest elevation in the Eastern United States, both fir and spruce are dying at a rapid rate, and the phenomenon is moving to lower altitudes. In some instances, it is taking only 3-4 years from the appearance of first symptoms to the death of entire stands, and spruce have been reported with six feet of dead crown from one year to another. These developments are posing the full range of options as to their causes, by now well

known in Europe: acidification of soils and a variety of secondary effects, direct action of acidity or nitrogen on foliage and ozone related damage. In other areas, spruce trees are also showing signs of ill health; in fact nobody seems willing to guarantee that there are any fully healthy spruce left at higher elevations in the Appalachians. At lower elevations, the evidence of reduced growth is mounting, based largely on coring programs.

The phenomenon of dieback has not touched commercial timber stands as yet. Commercial stands are found at lower altitudes, but there are signs of stress there as well, particularly reduced growth which reduces yield or delays return on investment. While it is moving to see forests in national parks affected, the commercial stands represent a vital political trigger which does not appear cocked in the United States yet. It is sad to have to say so, but when all is said and done, the commercial forest interests were decisive in getting action in continental Europe as well.

People respond very differently to dead and dying trees. Much has been made of the Germans' "love of forests"; dead trees are a common sight in the United States so that most people do not necessarily react in horror - they have all seen beaver ponds, and there are dead trees in most forests. Professionals on the other hand tend to repress evidence of dead or dying trees. We have seen that in Europe before the dam broke.

This issue will remain controversial for some time because not all groups are seeing the evidence the same way. No economic interests are pushing for action, and at present even the U.S. Forest Service denies that anything attributable to anthropogenic causes is happening. The State of North Carolina is fearful for its tourist industry (much like Black Forest communities until the revenue lost from decreased forest income threatened to be greater than the revenue lost from a drop in tourism).

It will be extremely difficult to get an overall assessment of forest decline in the Appalachians. The very precise West German figures on forest decline derive from a comprehensive, systematic annual census of all forests. This is possible only in totally managed forest systems; it cannot

be done in the typically unmanaged Appalachian forests. This will leave us with impressionistic overall assessments on the one hand, and cautious, isolated forest research based upon sample sites on the other.

The resulting picture is one of animated suspension: the United States has reduced acidifying emissions significantly over the past decade. Measures adopted by severl Northern states will probably ensure that this trend continues so that the United States may find itself close to compliance with the Helsinki Protocol without ever agreeing to attempt to meet its reductions. But this would still leave the central questions of any acid rain policy unanswered: have reductions occurred when necessary, where necessary and have they been equitably financed? To answer these questions the great American policy machine will need to be cranked up to produce an explicit solution: it is anybody's guess when this will occur, but if I were a betting person, I would put my money on 1989.

A STRATEGY FOR EUROPE
- THE SWEDISH VIEWPOINT

by
Goran Persson
Swedish Environmental Protection Board

The Acid Rain Problem is not unique

Yesterday's environmental problems could be solved at the local or at least at the national level. Today's most severe problems are transboundary and require concerted action by countries in large regions like Europe and North America. Tomorrow we will face global problems. Climatic changes caused by "greenhouse" gases and depletion of the ozone layer will be a challenge to all nations to rescue our spaceship Earth.

Acid deposition - better known as acid rain - is the best known but not a unique transboundary air pollution problem. Ozone, formed by photochemical reactions in the atmsophere with nitrogen oxides and hydrocarbons as the precursors and a suspect cause of damage to millions of hectares of European forests, has a similar transboundary pattern.

Metals like mercury, cadmium and - evident to all - caesium are being deposited thousands of kilometres from the emission source. The fishes in 5000 - 10000 Swedish lakes are unfit for human consumption due to the increased deposition of acids and mercury. Atmospheric deposition of cadmium gives a significant contribution to the on-going accumulation of cadmium on agricultural land.

The deposition of caesium and other radioactive substances from Chernobyl is a clear illustration that air pollution respects no boundaries. Who can question the existence of long range transport of air pollutants after the Chernobyl accident?

Other substances being borne by the winds over borders are

the persistent, bioaccumulating and toxic chlorinated hydrocarbons. The threat to the seal population in the Baltic Sea comes from the use of such substances in many European countries. Babies enjoying the mother's milk get a daily intake of dioxins ten times higher than the dose considered acceptable by a WHO working group. The cause is not a local source but dioxin emissions from combustion sources all over Europe. Dioxins have been measured in emissions from incinerators and motor vehicles. But it has also been shown that dioxin emissions can be significantly reduced or eliminated by efficient incineration and the use of catalytic converters.

A strategy for Europe must be based on the perception that we have a European problem and consequently nations have a joint responsibility for Europe's air and Europe's environment.

No more research as a substitute to action

For almost 20 years now, research has been steadily providing us with ever more information on the extent and effects of acidification. It may come as a surprise to many people to hear that we have been at it so long. Certainly the first reports of lakes becoming devoid of fish in Norway and Sweden, towards the end of the sixties, did little to arouse opinion, as compared with those announcing forest dieback in Central Europe in the early eighties. Of late, our knowledge of the effects on the soil has increased considerably, and the true image of acidification that is now emerging appears steadily more terrifying.

We know that acidification of the soil and water leads to changed conditions for plants and animals. The affected area is expanding, the soil is becoming acidified to an ever greater depth, with effects on more and more of the ecosystem. Even soil scientists have been surprised at the changes in the pH levels of the soil during the last few decades. The common view that forest soils are resistent to acidification is totally wrong. Studies conducted in Sweden, Norway, West Germany, and Austria all conclude that since the end of the second World War the soil has become five to fifty times more acidic.

So far depositions of sulphuric acid have been the main

cause of the soil and water acidification. In future, depositions of nitrogen substances are likely to have a relatively greater effect. When more nitrogen is added than plants need, the soil is said to be nitrogen-saturated, and nitrates will be leached out. Sulphates and nitrates passing through the soil carry simultaneously essential plant nutrients, such as calcium and magnesium, out of it. The acidification of forest soils leads to the conclusion that the question is not <u>if</u> forest growth will be affected,but <u>when</u>.

The present forest damages of about 7 million hectares in Europe can only partially be explained by soil acidification and nutrient deficiences. There is probably no single factor that causes forest damage. Episodic high levels of ozone in combination with other pollutants affect trees adversely and reduce their resistance to natural stress. Drought, frost or strong winds can then bring the trees above the tolerance limit.

It is no longer possible to evade the unpleasant truth - namely that acidification strikes hard at Europe's natural environment - by claiming that the measurements and research activities have either been inadequate in themselves or carried out over too short a period.

A Strategy for Europe

The time has now come to consider a European plan of action. The first step of such a plan is to define ecological target values for air quality and depositions in order to achieve a healthy environment and to compare these values with the present situation. The second step is to translate the necessary improvements in air quality and deposition into terms of emission reductions. The third step is to agree on the necessary strategies and time schedule to achieve the required emission reductions. The first two steps are scientific tasks, the third is a political one.

We have enough knowledge of the limits to Nature's tolerance to develop a European plan of action. The scientific evidence was recently assessed by a group of Scandinavian scientists. The results of their work was reviewed by international experts and is available in the report <u>Critical Loads for Sulphur and Nitrogen</u> from the

Nordic Council of Ministers. In June this year the approach was accepted by the Group of Experts under the Executive Body of the Convention on LongRange Transboundary Air Pollution. There exists, therefore, a broad scientific consensus about the levels to which pollution must be reduced to allow forests, soils and lakes to survive, or to recover.

To avoid large scale acidification of surface water, soil and groundwater, the deposition of sulphur should not exceed 0.5 g S/m2 a year. To avoid the serious consequences of nitrogen saturation of forest soil, the deposition of oxidized and reduced nitrogen should not exceed 1-3 g N/m2 a year. The present deposition levels in Southern Scandinavia is 2 g S/m2 and 2-4 g N/m2. In Central Europe nature may tolerate higher loads than in Scandinavia. On the other hand, the depositions are higher too, and the need for improvement is probably of the same size.

It is an important task for our scientists to produce a sensitivity map of Europe and compare it with the existing levels of deposition. Our modellers can then use this information together with the emission inventories to arrive at figures for the necessary emission reductions. We should not hide the uncertainties in this process but the main problem with a European plan of action is no longer in the scientific arena.

If we want to respect the limits set by Nature - and we have no choice in the long run - emission reductions for sulphur and nitrogen of about 80 and 50 percent respectively will have to be achieved. These figures include no safety factors.

We have the technical means for bringing about such reductions and the costs are not prohibitive. But have we got the political will? It is indeed a political challenge to agree on the necessary measures. We must ask ourselves if we want to be remembered as the generation that had the knowledge of the problem, had the technical and economic resources, but failed to use them for the benefit of mankind.

A European plan to control air pollution and acidification that can be agreed upon by the Signatories to the Geneva

Convention may perhaps not represent the best solution for all the countries concerned. We should of course aim at the best solution, yet still be ready to accept the second best, or even the third if need be.

One question is easy to identify, and that is:
on what principle should a national reduction of emissions to determined?

The now widely supported 30 per cent reduction of sulphur emissions, taking 1980 as the base year, is a simple approach which is important as a first step. But the achievement of a healthy environment in Europe will require much more than a 30 per cent reduction. In a European plan of action a still further reduction, with the same percentage for all countries, is only one of several alternatives. We shall have to study more closely the advantages and disadvantages of reductions expressed in amounts of sulphur and nitrogen oxides per energy unit of fuels. Some countries, too, prefer to regard the "pollution space" in the European airshed as something to be shared equally by all Europeans - which means a reduction of emissions to a level expressed in amounts of sulphur and nitrogen oxides per capita of population. The use of economic measures to achieve the least cost solution is an alternative that should not be ruled out.

National energy policies are of special importance to the solution of our problems of air pollution and acidification. In future, environmental protection must be considered as a much more important element than it is at present in the development of national energy policies by all European countries.

Today the budget for environmental protection measures in the energy field is negligible in some countries. In Sweden 4-5 per cent of the energy costs are attributed to environmental protection. We feel this figure is justified and it is widely supported by the public.

Environmental protection must also have a prominent place in the national transport policy. It's time for a red flag again. Not because there is much likelihood of motor vehicles frightening the horses, but because of what they are

doing to the environment.

A steady increase of about 2 per cent a year in the concentration of ozone in the troposphere has been observed for instance over the middle latitudes of the northern hemisphere. Here it is hydrocarbons, carbon monoxide, and oxides of nitrogen - the chief constituents of vehicle exhausts - that are of particular importance. Since the difference between the natural levels of ozone and those having effects on vegetation is quite small, there is every reason to be concerned over this development.

As regards the automobile, there are three basic requirements for its safe use. It must function safely (it does). It must be safe on the road (in that it is getting better). It must also be environmentally safe (which as yet it is not). We should bear this last in mind when debating the cost of effectively reducing pollution of the air through road traffic. A catalytic converter of the type that has been used in the United States and Japan for at least ten years may increase the cost of a car, say, by 5 per cent, depending on size and category. That additional cost is however no more than people are evidently willing to pay for lots of other extras. But let us <u>first</u> have converters, and then talk dashboards.

Because of these emissions of nitrogen oxides and hydrocarbons, the fact of forest dieback alone is sufficient to put the automobile in the front line for action. The next step to be taken within the framework of the ECE Convention on Transboundary Air Pollution must be a binding protocol for the reduction of these pollutants. A few countries in Europe, notably Austria, Switzerland, and Sweden, have already announced mandatory application of US emission standards for new cars. The compromise directive that is now being discussed within the European Community is totally inadequate. Anything that does not have the effect of improving the quality of the environment, as reflected in Europe's forests and lakes, during the next decade will always be inadequate.

Political damages

Let me conclude with a few remarks on the British policy.

Great Britain has a great capital of confidence among the Swedish people and among the people in the other Nordic countries. The British policy on environmental matters is rapidly consuming this capital. To throw your waste on the land of friendly neighbours is at best uncivilized behaviour and at worst, unwarrantable interference in the private affairs of another state, tantamount to a hostile act.

The British policy on environmental matters is not in Great Britain's own interest. Your image of "the dirty man" in Europe does not appeal to potential consumers of British goods in neighbouring countries. This image, which is quickly spreading among young people, may hurt the British economy and affect the number of jobs much more than a progressive and responsible environmental policy.

The Year 2000

For many of our transboundary and global environmental problems time is not on our side. There are scientists and decision makers who feel that the "chemical desert" is the most likely scenario for Europe. We must refuse to accept this attitude.

Let me end my presentation by quoting from an interview with the Swedish Prime Minister in the next issue of our Acid Magazine.

> "In spite of everything, I'm hopeful. A new environmental awareness hasgerminated among large sections of the community - and mainly among young people. We have capable researchers and scientists, and there is an international consensus in regard to their finds. So, all in all, I think better air and green forests will also be found on the other side of the year 2000."

THE PERSPECTIVE OF THE FEDERAL REPUBLIC OF GERMANY AND THE EUROPEAN PARLIAMENT

by
Beate Weber, MEP,
Chair, European Parliament Environment Committee

I should like to explain that, like William Waldegrave, I am wearing different hats today. First, I am an MEP, and that implies a particular perspective which does not necessarily always accord with that of the other constituent parts of the EEC - the Commission and the Council of Ministers - as well as the Parliament. Secondly, I am a German, which means that I might have some problems with other countries' attitudes - and specifically Britain's attitude - to air pollution control. Thirdly, you should be aware that I speak as a Socialist member of Parliament and thus my views might sometimes be in contradiction to those of the present Federal Government. For example, I do not agree with their lack of action on imposition of speed limitations, and I would be the wrong person to attack for that non decision.

Another point I wish to make concerns terminology. In Germany, we started by discussing this problem under the heading "Acid Rain". Soon after, we referred rather more to "Waldsterben" (which I shall be talking about later), but now we talk about "air pollution" since some people found a corner to hide when the terms of reference were restricted to acid deposition or acid rain. They would sometimes deny that a strict link with those phenomena and spcific forms or sources of pollution existed, and this would prevent them from listening to other arguments. Thus, we now talk about the whole package of air pollution and all the different substances involved, which will be my frame of reference today.

There was a well known election slogan used by the SPD in Germany in the 1960s - "The sky above the Ruhr must become blue again". This was the first campaign for cleaner

air in the Federal Republic, and it took place at a time when workers and residents suffered from heavy emission loads in this densely populated and industrialised area of North Rhine-Westphalia - and elsewhere.

North Rhine-Westphalia then became the first German state to enact an emission control act in 1962. This contained requirements for small and domestic emission sources. The state also enacted the first smog-orientated ordinance in 1964, and built up the first monitoring system, since greatly expanded.

Unfortunately, the need to deal urgently with the obvious air pollution problems led to some decisions that have subsequently proved to be short-sighted. High chimneys spread sulphur dioxide, dust particles, nitrogen oxides, heavy metals and all the other emissions from the steel industry and coal burning combustion plants far over Germany into regions that had never previously had problems with air pollution. As all other industrialised countries acted similarly to combat the problems of severe local pollution, and as combustion increased, air pollution ceased to be a regional problem and instead became a transnational, globalised problem.

Other measures taken in the 1970s paved the way for numerous, fundamental legal provisions in Germany. In 1971, the Federal Government, under the coalition of SPD and FDP, established the first environmental programme that covered the already all-important fields of environmental policy, and fixed the main objectives of the polluter pays principle and the principle of co-operation, and of precautionary or preventative measures. The Federal Emission Control Act (FECA) followed in 1974, accompanied by technical instructions for maintaining air purity - the first General Administrative Regulation. But, until the 1980s, when the public discussion about forest dieback began, things developed quite slowly, mainly with legislative and administrative measures which made Germany one of the more highly regulated countries in that field.

The attitude of European neighbours to Germany's concern about forest dieback was one of reluctant scepticism. They had already been affronted by Scandinavian fears about

damage to lakes and trees, and they knew about the very strange relationship of the older Germans to their woods and thought that the discussion was a revival of old Germanic myths. Until quite recently there was no equivalent English or French term for "Waldsterben"; now, regrettably, we have "le deparaissement des forets" in France, and "forest dieback" in the UK.

Both the political and the administrative systems started to move simultaneously in Germany in 1982 when the first shocking statistics of percentages of severely damaged forests were published. In 1983, the Council of Experts on Environmental Matters gave evidence on the dramatic situation regarding tree damage. In the East and North East of Bavaria, damage was estimated at 80% to 90% and these figures are borne out by the evidence of one's own eyes. When you visit the forest you see that in reality nine out of ten fir trees are dead or dying. The areas most affected were the northern and central part of the Black Forest, and in the Swebia-Franconian Forest. The damaged spruce trees were mainly found in the east and north-east of Bavaria as well, and in the central and northern highlands. At that time deciduous trees did not show any signs of damage, although foresters started to watch beech and oak more closely. Between 1982 and 1985 the situation changed rapidly. The total amount of tree damage as a percentage of forest area increased from 18% to 35.5% in Schleswig-Holstein, and from 5% to 46.6% in Hesse, 10 to 66.1% in Baden-Wurtenburg (the state where I live) and up to 77.3% in Hamburg - an increase of 21% between 1984 and 1985 alone. In 1984 one third of the total forest area in Germany was damaged.

To add a personal note, I was born in Bohemia, and the place where I was born was then black with forest but now there is not one healthy tree left in the whole region.

It was said that a 37% reduction in SO2 would cost about one billion DM. On the positive side, the effect of this would be to add to the economy 600 million DM worth of steel construction, and of course the damage caused by emissions is estimated at 3 billion DM at present. (This figure was from an OECD study, published about three years ago.)

To look at the damage figures another way, according to species, the following figures are for late 1984 (I have not yet had access to 1986 figures):

Spruce - 52.2%
Pine trees - 57.2%
Fir trees - 87.3%
Beech (raised in two years from nearly zero) - 54%
Oak - 55.3% (again, a huge increase with only 6% noted as damaged two years previously).

As to building damage, the cost of replacing the decaying sandstone on Cologne Cathedral amounts to about 5 million DM per year. While it is possible to replace sandstone destroyed by air pollution, and to go on doing this, it is not so easy to replace the people affected by polluted air, and a better solution would be to prevent the emissions in the first place.

The next stage of the discussion in Germany centered upon the question of whether air pollution abatement could really be afforded, or whether it had overall a negative effect on jobs and the economy as a whole. Studies performed not by ecological groups but by "serious" and neutral scientific/economic groups concluded that there were positive benefits for the economy in environmental pollution control. In the years between 1971 and 1977, 250,000 jobs were created or maintained by air pollution abatement. The new legislation just passed by the Federal Government will lead to industrial investment totalling several billion DM. Within the power plant sector alone, there will be an investment of 20 billion DM up to 1990. Yet the total cost of desulphurising all the German power plants is equivalent to just one unit of a nuclear powered reactor. It is up to you to judge that situation, but in Germany the general public is prepared to pay more, according to all opinion polls, if it is shown to be necessary to protect the environment.

At first, even within Germany, the public discussion about Waldsterben and air pollution attracted some cynical comments until the timber industry realised that the damage to the fir forests was an economic threat. "Waldsterben" was no longer the hobby of some eco-freaks, but the serious

business of economists, a business about which scientists, some politicians and some citizens groups had already been talking for years.

The media supported the case for action. Even the most conservative members of the media developed an environmental consciousness which initially took one by surprise. However, they took the opportunity of hinting that nuclear power plants do not emit acid gases - SO_2 and NO_x - which is undoubtedly the case, although the other side of the coin, the radioactive waste problems, were carefully not mentioned. Such comments ceased abruptly after Chernobyl.

Other air pollution issues attracted less attention in Germany - the health effects of pollutants - such as the impact of smog-laden air on bronchitics, or of lead in petrol upon children's developing brains, which received so much attention in the UK, did not attract the attention it deserved in Germany. Woods seem to be more important than children - or at least their lobby was stronger.

After the first wave of public discussion, people wanted decision and action instead of speeches. Things became more complicated when conservative scientists in Germany denied the linkage between air pollution and forest damage. The exact causal effect is difficult to determine, as far as trees and soil are concerned, although rather less difficult where buildings are concerned. Now, it is undeniable that SO_2, NO_x, CO and hydrocarbons are the major culprits. Between 1966 and 1982, total emissions of SO_2 in FRG remained more or less the same - between 3.2 and 3 million tonnes. The contribution of power stations to the total, however, was steadily raised from 41% to 62%, whereas industry's contribution was reduced, from 35% to 25%, and the heating sector's from 19.9% to 9.3%. NO_x levels increased to 3.1 million tonnes per year, with a notable increase in the contribution from traffic, up to 54%, from 40%. Again, there was a steady reduction in the industrial contribution, from 30% to 14%. Hydrocarbons emissions increased also, while carbon monoxide and particulates dropped, although the percentage contribution from traffic to particulate emissions increased from 2.6% to 9.4%. Clearly, the efforts to reduce industrial emissions were effective, while there are still serious problems with power plants and

traffic.

I shall not deal with the so-called "unconventional" pollutants - asbestos, benzene, heavy metals, PCBs - although their effects are surely detrimental to health as well. But the amount of these pollutants in air is still insufficiently monitored and controlled in the Federal Republic of Germany.

As to the political situation in Germany, the Green Party was founded and entered the Bundestag in 1982. Concurrently, there were moves for more legislation aimed at achieving clean air. Tougher legal restrictions on emissions from stationary and mobile sources were enacted, balanced by tax reductions and subsidies to help put these into effect. I now quote some passages out of a very recent book, Air pollution control strategies and policies in the Federal Republic of Germany, published by the Scientific Research Centre in Berlin, in co-operation with the Ministry of the Interior.

> "It is expected that these, together with the European legislation, will lead to massive reductions. The tendency now shifts from the broad approach of covering all emissions sources to a more selective problem and emission sources approach."

This is clearly to be seen in the TA Luft of 1985 that provides for selective interventions by responsible authorities. The large combustion plants ordinanace of 1983, and the stricter NOx standards adopted in 1984, were the most important steps. These measures are not yet in force, so that their effects cannot yet be determined and it is not yet certain that they will help to save the forests. At present, Germany has the most comprehensive and detailed air pollution control legislation of all European countries.

Nevertheless, there are some deficiencies. The German government has strongly opposed speed limitations for motor vehicles (I am now wearing my second hat). The proposals were for speed limitations on motorways of 100 km/hr, and for highways, 80 km/hr: the adoption of just the latter measure would lead to a reduction of NOx in air of between 41,000 and 70,000 tonnes per year. Other, substantial, benefits would be the savings in energy consumption and the

reduction in deaths on the streets.

It might be of interest to know a bit more about the difficulties that the Federal structure in Germany poses for pollution control activity. The FRG is very different from the other Member States of the European Community. West Germany is a Federal State, with eleven separate states each with strong legislative and executive powers. There is a strict division of powers in the field of environmental protection, which very often leads to problems. There is no exclusive jurisdiction for the Federal Government in the environmental field but only concurrent jurisdiction - ie, the state may act in the absence of Federal Government action or agreement between the Federal Government and the states, in the areas of noise abatement, exploitation of nuclear energy, waste disposal and air pollution control.

Framework jurisdiction gives the Federal Government power to establish framework legislation which must be implemented and enforced by the state, through their resposible agencies. Thus, the powers of legislator and executive are divided between the Federal Government and the states. The Federal Emission Control Act fundamentally changed the balance, producing more, yet still limited, power for the federation. However, ordinances and administrative rules passed by Bonn are subject to the consent of the state chamber - the Bundesrat. As a result of all this, the air pollution control system is rather too complex and I will not go into the details - it is almost too complicated for Germans themselves! The legal situation is very comprehensive and detailed. The Federal Emission Control Act of 1974 was amended in 1985 and there were 13 ordinances, up to and including the last one in 1983, on large combustion plant. These were supplemented by administrative guidelines and circulars, EC Regulations and Directives, and the ECE Convention.

The FRG is one of the Member States which have signed the 30% Protocol on sulphur emissions, but have not yet ratified it - as is the case with most of the 21 signatory states. Only Canada, Denmark, Finland, France, Liechtenstein, The Netherlands and Sweden have actually ratified the Protocol. It is incumbent upon us to ask our governments to do the same.

Despite this complex and far reaching legislation, some criticism has been levelled recently at the FRG. The system, though complex, is seen to be obscure and not particularly well targetted towards environmental need. The adminstrators of the system sometimes are lacking in comparison with the knowledge amongst the public interest groups. Furthermore, the target of the administrative effort sometimes seems to be off-centre - not targetted to where it is most needed. So German environmental policy is sometimes regarded as very expensive but not necessarily very effective. The emphasis on preventative technology is still lacking, and one of the main criticisms is that financial aid mainly helps the polluters, especially the electricity generators, and not those who suffer from pollution.

Now, I believe I should change my hat for the European Parliament one, although I want to wear this one only briefly since Stanley Clinton Davis has already covered the European legislation. What I want to focus on are the main issues concerning the European Parliament and the Environment Committee in the past few years. The first initiative within the European Parliament and the Environment Committee was with a report by Mr. H.J. Muntingh, a Dutch socialist, on Acid Rain. A public hearing was held in 1983, and at this the Parliament's main requirements were laid down; we asked for pollution curbs, measures to arrest European forest damage, and (perhaps most important of all) that we should enter into negotiations with the Eastern Bloc countries - a task that is now a little easier; and we called for effective co-ordination of scientific research. Then there were special discussions on photochemical pollution, comments on and amendments to the proposal on air pollution from industrial plants, now formulated as a Directive of 1984, measures on NOx from combustion plants, and an air quality standard, also in 1984, and then began the long and rather difficult history of the large combustion plant draft directive, with European Parliament amendments dating from 1984. The Parliament is still fighting to obtain some influence on the progress of this Directive, by means of consultation procedures.

There is always this difficult, tripartite procedure between Parliament, the Commission, and the Council of Ministers.

As you may know, Parliamentary rights are not yet as strong as Parliamentarians, at least, think they should be. A first report on exhaust gases from motor vehicles was compiled by Ken Collins in 1983; this was a most interesting initiative but it ended in 1985, rather unsatisfactorily. Eventually, after discussion by four committees of the Parliament - environment, energy, econmic and social, and transport - a compromise solution was reached which crossed both party and committee lines - and agreement was reached on standards equivalent to the current US standards, from 1 October 1986 - ie almost from this date, with exemptions only possible under specially defined conditions. The proposal also supported the immediate introduction of lead-free petrol in the Member States, and required special supportive measures to be taken by individual governments, through taxation etc, to promote the widespread use of lead-free fuel. In answer to a recent Parliamentary question, we obtained information about the relative speed of implementation of lead-free petrol, which varied widely from State to State - from about 2,100 petrol stations in The Netherlands, down to about 54 in France. In Germany at present we also have about 2,000 outlets for lead-free petrol. Unfortunately, when the proposal was in front of the Council of Ministers, they took far too lenient a compromise position with far too extended a timescale and too much protection for small cars. The European Parliament protested against this decision, as the increasing number of small cars would wipe out the slender decreases in emissions proposed.

A point always stressed by the European Parliament is that effective measures against air pollution can only be taken if the different sources - mainly large combustion plant and traffic, are tackled together as a package. We have always tried to keep up the pace of progress on the large combustion plant directive. However, there was strong contradictory pressure from some quarters, notably the UK, and even the German government which professed to be pressing for far stricter controls, was anxious that the directive should go no further than the current German measures - which is not to my mind a very European way of behaving.

I believe that I have given you an overview of the situation in Germany. It is, as you have seen, a positive one. At the

moment I believe we are less in need of new laws and regulations than of strict control measures and enforcement. We need to fulfil the measures laid down in the text of our statutes. By such means we may eventually obtain cleaner air by the end of the century - that is, if there are still some forests standing!

CONCLUSIONS

by
Dr David Clark, MP
Environment Spokesman, The Labour Party

Today we have heard repeatedly of the very real problems caused by acidic emissions in Continental Europe; notably dying woods and lakes in Germany and Scandinavia. The cost of this damage is enormous; recently the Swedish Environment Minister estimated that in her country alone it was 3.5 billion.

We would be foolish to imagine that Britain remains unaffected. Admittedly we have been buffered by favourable topography and climate, but the damage is nonetheless there.

This has been covered up by a smokescreen of silence manipulated by the Government who only last week were belatedly forced into action, albeit too little, by the CEGB.

Our water especially is being affected. Only this week, the BBC Science Correspondent confirmed that over 100 of Britain's lakes and rivers were now without fish, due to acidity.

Loch Fleet in Galloway has gone, Llyn Brianne in Central Wales is reported fishless, and detailed work on the Rivers Esk and Duddon in Cumbria, by the North West Water Authority, has found a number of stream sites fishless. Much of this increase has occurred in the last fifteen years.

Unless action is taken, it is only a matter of time before one of our major lakes in Cumbria dies. There is much fear amongst some scientists that Buttermere is nearest to the crisis point of becoming acidic. It would be tragic but nevertheless appropriate if this, the government of the balance sheet, should be responsible for destroying aquatic life in Buttermere, in the heart of the Lake District, which

has inspired countless generations.

Given the prevailing winds, and the geography of sites most affected - central Wales, the Lake District and Galloway - it may be that not all the acidic emissions are from Britain.

If our power stations are producing these poisonous emissions, the ones in Eire and Northern Ireland are doing likewise. The power stations of Northern Ireland at Ballylumford, Coolkeeragh, Kilroot and Belfast West, along with those in Eire, especially the new one at Moneypoint, are real dangers to the United Kingdom.

Our Government, now having admitted that power stations do produce noxious fumes, ought to raise this issue with the authorities in Eire as well as taking action themselves in Northern Ireland. A Labour Government would do so.

This Government's prevarication and failure, even now, to take the necessary action to tackle the acidic emissions, has not only led to our being detested in Europe, as was witnessed in the Oslo demonstrations against Mrs. Thatcher, but even more important, they are responsible for irreparable damage to some of our most beautiful countryside.